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# Evolution education in light of religious science teachers' and scientists' conceptions of evolution and religion

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## Abstract

**Background:** The presumed conflict between religion and evolution is considered one of the main causes of rejection of evolution worldwide. However, there is a unique group of religious people who accept, study, and teach evolution. The aim of this study was to gain a better understanding of these individuals' conception of the relationship between evolution and religion, and the factors that influenced this conception. Religious biology teachers ( $n = 10$ ) and scientists ( $n = 10$ ) were surveyed and interviewed about their conception of evolution and religion and the factors that influenced it.

**Results:** The study population demonstrated that reconciling science and religion was possible for them. The interpretation of the bible as moral guidance, and not as a science book, was found to be a main idea in the participants' conception. Most participants said that their conception of evolution was influenced by their parents' and teachers' approach to science. Participants who had rejected evolution in the past emphasized that exposure to scientific knowledge alone was not enough to counter this rejection, whereas exposure to the possible compatibility between religion and evolution promoted their acceptance.

**Conclusions:** These findings suggest the importance of exposing teachers to different approaches to the relationship between evolution and religion. Implementation of the study conclusions in professional development programs may help teachers promote religiously affiliated students' better learning of evolution and a meaningful learning of science in general.

**Keywords:** Evolution education, Religious scientists and teachers, Religious scientists' conceptions, Religious teachers' conceptions

## Background

### Religiosity and acceptance of evolution

Evolution is one of the most controversial scientific issues among the general public. The public controversy stems mainly from a presumed conflict between religion and evolution, which is one of the main sources for the high proportion of rejection of evolution around the world,

in a wide range of cultural and geographical contexts (Barnes et al. 2021; Deniz and Borgerding 2018; Hameed 2008; Miller 2006; Sbeglia and Nehm 2020). The notion that to accept evolution one must become an atheist is the most threatening aspect to the learning of evolution (Lyons 2010). Gallup polls consistently find that a person's religious affiliation is related to acceptance or rejection of evolution (Gallup 2017).

One of the factors leading to the high proportion of individuals who perceive a conflict between religion and science are scientists, religious leaders and politicians who propagate this message of conflict in classrooms,

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religious institutions, popular culture, and the media. Some religious leaders promulgate the conflict by claiming that evolutionary theory must contradict religion and religious faith (Barnes and Brownell 2017). Some researchers who study evolution education even claim that: “Harmonious coexistence between science/evolution and religion is illusory. They are destined to interact in conflict due to the inherent incompatibility between scientific rationalism/empiricism and the belief in supernatural causation” (Paz-y-Miño-C and Espinosa 2013).

The perceived conflict between evolution and religion may be exacerbated by differences in religious cultures and religious beliefs between scientists and the public (Ecklund et al. 2016). Academic science has a disproportionately large number of people raised with no religion, potentially producing many more people who do not believe in God (Ecklund and Schitle 2014). Evolutionary biologists have the lowest rate of religiosity among any discipline polled (Graffin and Provine 2007). Whereas the public struggles with how to situate their religious beliefs with claims of evolutionary theory, many biologists are unlikely to experience the same struggles (Alters and Nelson 2002). However, it was found that when scientists think their peers have a positive view of religion, they are less likely to agree there is a conflict between science and religion (Ecklund and Park 2009). In a study that examined religion among academic scientists in the USA, Ecklund and Schitle (2014) found that scientists who identify themselves as Jewish were the only religious identity category in the study population that has a much higher proportion of religious adherents than the general population (most identify themselves as reformed or liberal). In addition, Dunk and Wiles (2022) found that acceptance of evolution among Jewish students was the highest compared to students who identify themselves with other religions. Examining the perception of orthodox Jews who accept religion and science may help in understanding this phenomenon.

Accepting the concept of evolution is important for the advancement of biological sciences and has many implications for individual citizens’ daily lives. Not accepting biological evolution limits people’s ability to make informed decisions about a wide range of phenomena that have personal and global ramifications (Nadelson and Hardy 2015). Religiosity, the main factor influencing acceptance of evolution, explains far more variability than the understanding of evolution, and as religiosity increases, acceptance of evolution decreases (Allmon 2011; Alters and Nelson 2002; Barnes and Brownell 2017; Eve et al. 2010; Winslow et al. 2011). Students’ religious beliefs have been shown to be the main factor predicting whether they will accept evolution (Truong et al. 2018; Unsworth and Voas 2018), although recently Barnes et al.

(2021) demonstrated that students’ perceived conflict between religion and evolution is a better predictor of acceptance than religiosity or understanding.

Despite the common notion that religious beliefs conflict with evolutionary theory, many philosophers, theologians and scientists have discussed a range of possible ways to view potential compatibility between evolution and religion (Pear et al. 2015; Yasri et al. 2013). In addition, 16,000 religious leaders (Christian, Jews, and Buddhists) signed a letter supporting potential compatibility between evolution and religion, known as “the Clergy Letter Project” (Zimmerman 2018). Therefore, there are religious solutions to the conflict, although they are unlikely to be commonly known among the general public, as already noted.

The controversy around evolution and religion is one particular example of the larger relationship between science and religion, which presents a complex history of interaction that includes frequent controversy and mutual suspicion, but also ongoing cooperation and accommodation (Shane et al. 2016; Yasri et al. 2013) provided a comprehensive review of the various taxonomies described in the literature and summarized the different views according to their similarities and differences (see “**Methods**” section below). In addition to synthesizing a taxonomy, Yasri et al. (2013) developed a standardized research tool, based on that taxonomy, that enabled identifying the different views of their research objectives and comparing existing and future studies. The tool used by Yasri et al. (2013) is presented in detail in “**Methods**” section.

#### **Acceptance of evolution in Israel**

Israel is a multicultural country. Most of its population is Jewish (74.1%), 21.0% is Arab (Muslim, Christian and Druze), and other minorities make up the remaining 4.9% (Israel Central Bureau of Statistics 2019). The Jewish population is composed of 44% who define themselves as secular, 35.1% as traditional, 10.9% as religious (modern Orthodox), 9.7% as ultra-Orthodox, and 0.3% unknown (Israel Central Bureau of Statistics 2016). A survey that examined Jewish Israeli beliefs showed that 80% of the Jewish population in Israel believes in god (Arian and Keissar-Sugarmen 2012). When Israeli Jews from different sectors were asked to choose whether: “humans and other living things: have evolved over time” or “have existed in their present form since the beginning of time,” about half of them (53%) chose the first option, indicating an acceptance of evolution, while 43% chose the second option, indicating rejection of evolution. The percentages of those who accepted evolution among each sector were: 83% of secular Jews, 35% of traditional Jews, 11% of modern Orthodox Jews and 3% of ultra-Orthodox Jews (Pew

Research Center 2016). Thus, as most religious people in Israel tend to reject evolution, we sought to understand the conception of the minority religious people who do not reject evolution. The study population was composed of modern Orthodox and ultra-Orthodox Jews who accept evolution.

### Rationale and research questions

As already noted, evolution is one of the most controversial scientific issues among the general public, mainly because of a presumed conflict between religion and evolution. However, there is a unique group of religious people who accept, study, and teach evolution. Understanding how religious scientists and teachers reconcile these seemingly contradictory domains of their lives—evolution and religion, and the factors that influence their conception of them, is important for evolution education for several reasons: first, as we have shown previously (Stahi-Hitin and Yarden, 2022) many teachers in Israel report that their students reject evolution because of a presumed conflict between evolution and religion. The scientists and teachers who were chosen for this study are religious and see no contradiction between religion and evolution; therefore understanding their conception of these topics may help teachers become familiar with possible answers for their students. In addition, understanding the factors that shaped the participants' conceptions may help in creating useful teaching strategies toward students accepting that there is no contradiction between religion and evolution.

In this study, we attempt to answer the following research questions:

1. How do religious biology teachers and scientists conceive the possible relationship between religion and science in general, and evolution and creation in particular?
2. What do the participants feel influenced their conception of the possible relationship between religion and science?
3. What additional factors might have influenced the participants' acceptance of evolution?

## Methods

### Population

The participants of this study were religious biology teachers ( $n=10$ ) and scientists ( $n=10$ ). Their academic degrees, ages, and Measure of Acceptance of the Theory of Evolution (MATE) questionnaire (Rutledge and Warden 1999) scores (see below) are shown in Table 1. All of the participants defined themselves as modern Orthodox, except S7, who defined himself as ultra-Orthodox.

**Table 1** Participants' profile ( $n=20$ )

Code <sup>a</sup>	Education <sup>b</sup>	Age	MATE
T1	MSc (ST)	33	89
T2	PhD (ST)	54	92
T3	Ma (ST)	27	95
T4	PhD (ST)	80	86
T5	PhD (ST)	52	80
T6	BEd (ST)	38	95
T7	PhD (STS)	43	99
T8	MSc (BIO)	48	65
T9	MSc (ST)	63	85
T10	BSc (BIO)	63	65
S1	PhD (STS)	43	94
S2	MSc (BIO)	46	89
S3	PhD (BIO)	41	85
S4	MSc (BIO)	28	100
S5	MSc (GEO)	32	100
S6	PhD (ANT)	39	80
S7	PhD (BIO)	27	74
S8	Professor (BIO)	47	100
S9	Professor (GEO)	57	94
S10	PhD (BIO)	37	94

<sup>a</sup>T: teachers, S: scientists

<sup>b</sup>The different disciplines of the participants—ST: science teaching; STS: science, technology, society; BIO: biology; GEO: geology; ANT: anthropology

Seventeen of the participants learned evolution through formal academic education and biology lessons in high school. Three teachers—T5, T8, T10—learned evolution through informal means, such as general courses and museums.

## Research design

### Pre-interview questionnaire

The participants received an online questionnaire before the interview (Appendix 1 25) in which they were asked to answer demographic questions (to understand the variation in the sample), such as their age, education, self-religious definition, and whether they think there is a conflict between evolution and religion, ranked on a 1–5 Likert scale. To assess the participants' level of acceptance of evolution, they were asked to answer the MATE questionnaire, which has been used as a main tool to assess acceptance of evolution in different populations (Rutledge and Warden 1999). The questionnaire consists of 20 items ranked on a Likert scale, with each item assigned 1–5 points, so that possible scores for the MATE range from 100 (highest acceptance) to 20 (rejection).

As the MATE was criticized in the literature (e.g., Neumann et al. 2011; Smith 2010), choosing it as the instrument for assessing acceptance may add a limitation to the research (see “Discussion”), but as it was used as a secondary tool and triangulation was conducted using two additional methods, we believe the effect is negligible.

**Interviews with teachers and scientists**

Religious biology teachers and scientists (n = 20, Table 1) were interviewed in a semi-structured in-depth interview of 90 min (on average) about their conception of evolution and religion and the factors that may have affected it, including whether they had rejected evolution in the past and their source of knowledge about evolution. The goal was to obtain in-depth explanations of their conceptions of the science–religion relationship in general and the evolution–creation controversy in particular (Appendix 2 26). Two possible limitations of the interviews are important to note: (1) most of the data relating to the participant’s experience in the past are based on their self-report; In addition, (2) the interviewer was religious, and this could be easily recognized by the participants.

**Views on the relationship between science and religion**

For analysis of the interviews, we used Yasri et al.’s (2013) taxonomy of the different views on the relationship between science and religion, according to their similarities and differences. The taxonomy grouped the views into those that considered science and religion to be incompatible [Compartment, Science Trumps Religion (STR), Religion Trumps Science (RTS)], and those that found them to be compatible (Different Questions, Different Methods, Coalescence, Complementary); see details in Table 2.

In addition, Yasri et al. (2013) developed a short questionnaire to identify the different views of science and religion held by research subjects (teachers, students,

etc.): the Science and Religion Self-Identification Inventory (SRSII). After being interviewed, the participants were asked to fill out the SRSII, in order to triangulate our analysis of the interviews and to better describe the interviewees’ view.

**Data analysis**

**Quantitative approach**

The answers to the MATE and SRSII questionnaires were coded into predetermined categories (Rutledge and Warden 1999; Yasri et al. 2013) and the MATE score was calculated for each individual participant, as well as for different subgroups of individuals that arose from the data (role, education, views of the relationship between science and religion, source of evolutionary knowledge, and past rejection of evolution). Correlations between the MATE scores of the different subgroups were examined. The results were statistically analyzed using the Statistical Analysis Software (SAS) program for both descriptive statistics and comparing frequencies (chi-square).

**Qualitative approach**

The qualitative analysis of the interviews with the teachers and scientists was a combination of inductive and deductive analyses (Cho and Lee 2014).

Inductive analysis was used in order to identify the participants’ religious and scientific views, and to understand the factors that influenced their views. First, the transcripts were read by the first author, who also performed an open coding process by writing memos on themes emerging from the data. Then, both authors read 10% of the transcripts and created initial categories from these themes. Citations that answered the categories were pulled out into a table that enabled a crosswise analysis of each question. Subsequent reading of each transcript enabled to identify additional themes. Then, all the

**Table 2** Summary of the views on the relationship between science and religion according to Yasri et al. (2013)

	Views	Description
Incompatible	Compartment	Conflict exists in the explanations provided by science and religion, but neither explanation should take priority
	Conflict	Science trumps religion (STR) When there are different answers to the same question, only science provides true answers
	Religion trumps science (RTS)	When there are different answers to the same question, only religion provides true answers
Compatible	Contrast	Different questions There is no conflict between science and religion because their role is to answer different questions
		Different methods There is no conflict between science and religion because they construct knowledge in different ways
	Consonance	Coalescence It must be possible to combine science and religion because they provide the same answers to the same questions
		Complementary Both science and religion are useful for understanding all aspects of life

transcripts were coded according to the initial codes (the coding rubric appears in Appendix 3 29).

The deductive analysis was conducted in order to define the participants' views toward the relationship between science and religion, according to the pre-determined categories that appeared in the classification of Yasri et al. (2013). The interviews were read several times and all the citations from the interviews in which the participants talked about their approach toward science and religion were pulled out and the authors coded them independently according Yasri et al. (2013)'s framework.

### Validity and reliability

To minimize any bias due to prior assumptions or experiences, the data were validated by two researchers to capture a wider view of the data analysis. Initially, the authors conducted an open coding process, in which each author identified the sub-categories emerging from the data; a discussion was then held between the authors. This process was reiterated three times, starting from 80% agreement, until 100% agreement between the authors was reached.

The Cronbach coefficient alpha of the MATE questionnaire was 0.926. We chose to analyze the results according to the categories offered by Rutledge and Sadler (2007).

During the interrater reliability process, the second author independently coded 15% of the coded interview excerpts, using the coding rubric (Appendix 3). When disagreements occurred, the researchers discussed the code until reaching an agreement. This process was held three times, at first the Cohen's Kappa [that represents the level of agreement between coders (Fleiss 1981)] was 0.70, after the first discussion Kappa reached 0.95 until achieving 100% agreement between coders with Kappa = 1.

### Results

Because we wanted to examine the research participants' perceptions of a possible contradiction between religion and evolution, they were asked in their pre-interview questionnaire to rank the degree of contradiction between evolution theory and religious faith on a Likert scale: 1—no contradiction, 5—there is a contradiction. Eighteen participants answered that there is no contradiction, and two participants chose 2—slight contradiction, because of the philosophical interpretation of the theory.

In addition, we examined the individual participants' MATE scores, which appear in Table 1. The average score

**Table 3** Average scores of the MATE questionnaire separated into levels of acceptance according to Rutledge and Sadler (2007)

Acceptance level	Teachers	Scientists	Average MATE score
Moderate (65–76)	2	1	68
High (77–88)	3	2	83.2
Very high (89–100)	5	7	95.08
Total	10	10	88.05

of all of the participants was 88.05 (Table 3), which is considered a high level of acceptance of evolution (Rutledge and Sadler 2007). Cronbach's alpha for the total questionnaire was 0.926.

### Participants' conceptions of science and religion

To examine the participants' conceptions of the relationship between science and religion, as well as evolution and creation (research question 1), we interviewed them, and they were also asked to fill out the SRSII questionnaire. Below we describe the religious and scientific conceptions of the participants, and then we describe their conception of the relationship between religion and science, as well between evolution and creation.

In their interviews, all of the participants indicated that both religion and science hold great importance in their lives, and most of them emphasized the need to characterize each discipline and its role in their lives, because they are fundamentally different. In addition, they indicated that they do not feel that they must accept one and abandon the other and truly accept both, and that the presented dichotomy is false. For example they said:

*As a religious person, studying evolution strengthened my religious faith. (T3)*

*I never had a feeling that I must choose only one of the ideas [evolution or religion]. What if people don't want to choose only one idea? Why force them to choose? I think this causes unnecessary problems. (S1)*

### Religious conception

Nineteen of the participants described themselves as modern Orthodox, and one as ultra-Orthodox, and most of them had a similar religious conception, with a few exceptions. All interviewees except one (T10) emphasized that the purpose of the scriptures is not to describe

science or history. The following statement appeared in similar versions in 19 interviews:

*The Torah is not a science or history book, but provides moral guidance.*

The participants mentioned the different values that they learned from the scriptures, as a deep moral story that teaches them how to live their lives—how to be closer to god, how to create social connections, the responsibility of man toward nature, etc. Eleven participants mentioned Rambam (Maimonides), who lived in the 12th century and is considered one of the most rational figures in Judaism, as a reference to the idea that the creation story, like many other things in the scriptures, cannot and must not be understood literally; those who do take these stories literally are missing the point.

*The literal understanding is like imagining god building sand palaces. Every other image is so concrete that it makes the creation story wrong. Moreover, it is forbidden, since one of the Jewish principles of faith according to Rambam is that god “has no body and he is free from all of the properties of matter.” (T9).*

All of the participants but one (T3) mentioned, during their interview, different rabbinical attitudes on this issue, emphasizing the participants’ tendency to rely on religious sources of authority, which is common among religious people.

The controversy between arbitrary nature and divine providence was emphasized by the participants as one of the most fundamental questions in the relationship between science and religion. All participants said that they believe in divine providence, although they cannot understand or explain how it works because this is a philosophical interpretation, and no philosophical interpretation can be proven—not even an arbitrary one; both are legitimate philosophical explanations of nature that cannot be proven or disproven by scientific tools:

*Things may look arbitrary, and that is OK. However, I can believe it is not arbitrary, because science cannot explain or prove that things are arbitrary since this is not science but philosophy. (T4)*

The participants emphasized the controversy between arbitrary nature and divine providence as a fundamental issue for every religious person, not only in the context of science and religion, but in almost all areas of life. Religious people live in both dimensions—the spiritual and the materialistic—and they are skilled at finding a divine influence in processes that appear to be random:

*When we go to the doctor and still pray for our*

*health, we don’t really understand these two parallel dimensions—the physical and the spiritual. That is a question we all try to answer but we do not necessarily have all the answers. Evolution is just one example of how we cannot understand the connection between the two dimensions. (S1)*

### **Scientific conception**

The interviewees’ scientific conception was not explicitly addressed in the interviews. However, all of the participants mentioned some characteristics of science that expressed an understanding of the nature of science as a method that best describes reality in the present. Eleven participants said that science is tentative and is not an absolute truth, but it is important to note that this is not a reason to reject it. For example:

*A scientific theory is not an absolute truth, but it is the best explanation that scientists can give today for various natural phenomena. It is true that in the future, more discoveries will expand our knowledge and the theory may change, but for now we are studying the height that humanity has reached—and it is a great thing! (T7)*

Eight participants declared that they trust science but are aware of its limitations, and four participants also emphasized the difference between observations and interpretations of scientific findings. Two teachers—T8 and T10—made exceptional statements that suggest that they doubt the scientific method. This seemed to be in line with their MATE score, which was the lowest among all participants (Table 1). These statements were:

*Science is final for now. I do not say it is not true, but it does not scare me. They can say whatever they wish; tomorrow they will say something else. (T8)*

*The attempt to find the age of the universe is based on many speculations. We cannot know exactly what happened. So if the scientific truth is based on a speculation, why should it contradict my faith? My faith is one of the speculations. (T10)*

### **The relationship between science and religion**

As already noted, after the interviews, the participants were asked to answer the SRSII questionnaire. This questionnaire was aimed to help in triangulating the participants’ preferred attitude toward the relationship between science and religion with what was said during the interviews. In Table 4 it can be seen that all of the respondents agreed with more than one statement, with an average of

**Table 4** The number of respondents to each statement of the SRSII questionnaire according to the various agreement levels (n = 20)

	Incompatibility			Compatibility			
	Compartment	STR	RTS	Contrast (different:)		Consonance	
				Questions	Methods	Coalescence	Complementary
Strongly agree	0	1	0	11	10	2	17
Agree	2	1	0	8	6	1	2
Not sure	1	2	4	0	1	6	0
Disagree	11	7	6	0	1	7	0
Strongly disagree	6	9	10	1	2	4	1
Best describe personal view	0	0	0	5	2	0	13

three statements with strong agreement/agreement. The statement representing the *complementary* view had the highest agreement level. Namely, 17 respondents strongly agreed with it, 2 respondents agreed, and only 1 disagreed. In addition, *complementary* was chosen by most respondents (13) as best representing their personal view.

The second popular view was *contrast*; 11 respondents strongly agreed and 8 agreed with the statement representing the *different questions* view; 10 respondents strongly agreed and 6 agreed with the statement representing the *different methods* view; 7 participants chose *contrast* as best describing their personal view (Table 4).

Views that represent *incompatibility* between science and religion were ranked as disagree/strongly disagree by most respondents; 17 respondents disagreed with the statement representing the *compartment* view; 16 respondents disagreed with the statements representing *STR* and *RTS* views. However, 4 teachers agreed with these views—2 with the *compartment* view and 2 with the *STR* view. It is important to note that none of the respondents chose these views as best describing their personal view; rather, all of them chose the compatible views (Table 4, bottom row).

In their interviews, each participant was asked about his preferred attitude toward the relationship between science and religion, as well as between evolution and creation. The three main attitudes that were mentioned in the interviews were *contrast*, *complementary*, and *coalescence*. We describe each of them below.

**Contrast:** Twelve participants emphasized the idea that each domain, science or religion, deals with different subjects and therefore should be understood according to its own rules. For example, one of them said:

*Religion and science are not defined by the same principles and values and are measured in a completely different manner. My faith should not fit the criteria that my science should fit. What is my faith*

*worth if a new discovery of a snake with legs disputes it? (S5)*

**Coalescence:** Four participants emphasized the idea that there is a complete fit between scientific findings and biblical stories. Three teachers (T2, T8, T10) and one scientist (S2) declared this view explicitly in their interviews, although they made some statements that indicated a mixture of approaches. For example:

*I prefer the coalescence approach, but I think that to understand coalescence you should understand that each (science and religion) talks about different issues. I agree with the idea that man was created mature, with the rest of the world mature—not seeds and sprouts. There are developments all the time, and the world may have been created in that way. I don't know, it is one possibility... (T8).*

**Complementary:** Four participants emphasized that science and religion cannot be in conflict because they exist in different dimensions. One cannot replace the other; each has its role in life, and they complement each other to create a whole world view. For example, one of them said:

*There are two levels of reality. There may be a god that supervises nature, but he acts through natural mechanisms and rules, and there is no contradiction between the two. (T7)*

When the participants' approach to the science–religion relationship as declared in the interviews was compared to their approach as declared in the SRSII questionnaire, inconsistencies were found (Table 5). Seven participants declared one approach in the interview, whereas they declared a different one in the questionnaire (marked with an asterisk in Table 5). It is important to note that those people strongly agreed on the questionnaire with both approaches—contrast and complementary—but when

**Table 5** A summary of the combinations of approaches that the participants indicated as best describing their personal view, according to the questionnaire and interview, and the number of participants who showed each combination

According to SRSII questionnaire		According to the interview	
Approach	#Participants	Approach	#Participants
Contrast	7	Contrast	6
		Coalescence	1 <sup>a</sup>
Complementary	13	Contrast	6 <sup>a</sup>
		Complementary	5
		Coalescence	2 <sup>b</sup>

<sup>a</sup> Interviewees declared one approach in the interview and a different approach in the questionnaire

<sup>b</sup> These two teachers talked in the interview about the coalescence view, but also had motifs of the complementary view, and their answers were therefore not considered to be inconsistent

asked to choose one of them, they may have felt “pushed into a corner.”

#### Factors that influence the participants' acceptance of evolution

All participants (except T3) emphasized that their conception of evolution was influenced by the positive/negative approach to science of their family or teachers.

**Family:** Ten of the interviewees emphasized their parents' role in shaping their own conception of evolution. They said that they received, from their parents and from home, an attitude of openness to learning and accepting science and religion. Some mentioned going to nature museums that had dinosaurs with their family, and the feeling they got from their parents that it does not contradict any of the religious values that they had grown up with. For example, one of them said:

*I grew up in an educated home, in which these things were never an issue...I remember going to a museum with dinosaurs—wow! Bones of dinosaurs that lived 80 million years ago. Cool! We did not even think that something is odd. (S10)*

Even though most of the participants in this group grew up in an educated home with scientific tendencies, three of the interviewees (T3, T6, and S4) mentioned growing up in families with a neutral/negative view of science. Some of them mentioned that their family members explicitly objected to evolution. For example:

*I grew up in a traditional, non-religious family. Once, I told my family that I was studying evolution and then my brother said: “Evolution?! That is a lie!”*

*He was very upset with me. He is not religious, but there is something in the traditional conception that treats ‘evolution’ as a curse word. (S4)*

Despite the approaches of their families and their society, these three participants never rejected evolution. The three mentioned that they were very interested in science in their childhood, so this could have influenced them, as described by T3:

*I always perceived science as a reliable discipline, and I always loved biology. So if I love biology and I love Judaism, they must be compatible. If a scientist said this is true—so it is true, and we just need to find the explanation. (T3)*

**Teachers:** Thirteen of the interviewees emphasized the role of their school and teachers in shaping their conception of evolution, and of science in general. Nine of them mentioned that their teachers had taught them to be open to new ideas, and that they could be religious and also be highly educated without fearing foreign ideas. For example, one of them said:

*I had great teachers in high school who taught us to be open-minded. We were not limited by them, everything could be questioned. (T4)*

On the other hand, four participants mentioned that their teachers emphasized the conflict between evolution and religion. They will be discussed further on.

Additional factors that might have influenced the participants' acceptance of evolution were examined by comparing the average MATE scores of different subgroups of interviewees (Table 6). In each subgroup, the significance of the correlation between each criterion and the MATE score was calculated using the Wilcoxon two-sample test.

For three categories—role, education, and view of the relationship between science and religion, the difference between the total MATE scores of the two subgroups was not significant. The subgroup of participants who had always accepted evolution had a significantly higher MATE score than the subgroup of participants who had rejected evolution in the past. The subgroup of participants who received formal evolution education (such as through academia or high school) had a significantly higher MATE score than the subgroup of participants who learned evolution by informal means (such as books, museums, media).

To learn about the factors that shaped their conception of science and religion and their acceptance of evolution, the participants were also asked in the interview about



**Table 6** A comparison of the average mean MATE scores between different subgroups of participants according to different categories of comparison (role, education, SRSII results) and its significance

Category (tool)	Subgroup	Number	MATE mean score	STDV	Wilcoxon value (w)	p
Role (pre-questionnaire)	Teachers	10	85.1	11.96	119.5	0.1504
	Scientists	10	91	8.94		
Education (pre-questionnaire)	Undergraduate, MSc	9	87	13.44	97.5	0.4253
	PhD—Professor	11	88.9	8.46		
View of the relationship between science and religion (SRSII)	Contrast	7	89.14	11.56	82	0.5317
	Complementary	13	87.46	10.66		
Past rejection of evolution (interviews)	Always accepted	14	90.72	10.36	37.5	0.0261
	Past rejection	6	81.83	9.54		
Source of knowledge in evolution (interviews)	Formal	17	91.23	7.42	7.5	0.0109
	Informal	3	70	8.66		

their past attitude toward evolution. According to their answers, two main groups were identified: those who have always accepted evolution ( $n = 14$ ), and those who had rejected evolution in the past ( $n = 6$ , Table 6).

#### From rejection to acceptance

According to the interviews, 14 of the participants indicated that they had never felt any conflict between evolution and religion. Their religious view never made them feel uncomfortable with the idea that humans and other organisms evolve through time, mainly because they never thought that the scriptures should be understood literally. Six of the interviewees indicated that there was a time when they objected to evolution, some during high school, and some even after graduating with scientific degrees. For example:

*Even after I finished my MSc, I had never studied evolution properly, and I was more of a creationist. The idea that the world is millions of years old was quite hard for me. I remember looking at a dinosaur skeleton and I was skeptical about it. I thought most of it is reconstructed, most of it is not real. So, we can't predict the dinosaur's size with any certainty based on a few bones. (T5)*

When asked why they rejected evolution, they mentioned the following reasons.

**Lack of knowledge:** This was mentioned by 3 interviewees as the main reason that the general public rejects evolution. It was also repeated among the interviewees who had rejected evolution in the past, in their words, because they just didn't know what evolution was:

*When you are opposed to something that you don't really know—you don't understand what you are opposed to. It doesn't come from knowing or think-*

*ing—it comes from a primitive lack of knowledge. (S6)*

*I found an exam from when I was in high school, and there was a question on evolution, and beside the answer I wrote: "This is my answer, but I don't believe in it." It was because no one taught us evolution properly, we had to read the book by ourselves. (T2)*

**Authority that emphasized the conflict:** Four participants mentioned teachers in school or at university who emphasized the conflict during class, by delegitimizing religion or evolution:

*The lecturer in the evolution course said that the bible is a fairy tale and we were very angry. I don't know why I was so anti-evolution, maybe because the lecturer was anti-religious so it felt that everything related to evolution is necessarily anti-religious. (S6)*

*I had an ultra-Orthodox science teacher in high school so I'm sure it influenced [my perception of evolution]. I think it may have limited us. (T5)*

**Social objection:** Three participants mentioned the influence of the general society in which they grew up. They mentioned absorbing the idea that evolution rejects religion from different sources, such as youth organizations, friends, media, etc., but they could not pinpoint a specific origin of that perception. For example, one of them said:

*It is like something that you can't touch. You see a church, but you don't get to go in. It's not mine. It's not for me. (S6)*

Despite their past rejection of evolution, eventually, these participants accepted it. They indicated that exposure to scientific knowledge alone was not enough to eliminate their objection, because all of them had basic evolutionary knowledge; rather, it was exposure to various religious authorities that offered explanations for the compatibility of religion and evolution—books, lectures, courses, etc., which promoted their acceptance of evolution. Since the participants' rejection of evolution had led to the conception that evolution and religion must be in conflict, being exposed to various explanations of the compatibility between them had an important influence on promoting their acceptance. Specifically:

*The first time that I heard that the timetable of the Book of Genesis is not day after day, and that the concept of time there is different than the one we know today, it helped me realize that I don't need to be afraid and that science and religion can be compatible. (T5)*

*When I was exposed to religious books that expounded the idea that the genesis stories are allegories, and that the first commentators also thought so, I said to myself—OK. It [evolution and religion] is compatible. It solved the problem for me and from then on I felt free, it was as if the fog had lifted and the world had opened up. (S3)*

It is important to note that all participants (except T3), those who had rejected evolution in the past and those who had not, mentioned one or several religious authorities upon which they rely—rabbis or commentators—who helped them shape their world view. Thus, the idea alone was not enough, and the religious authority that represented the idea was very meaningful:

*I am willing to adopt the approach of the Jewish philosophers who explored the issue deeply enough and concluded that there is no contradiction between religion and science. I don't rely only on myself; they are authorities for me and I can rely on their opinion. (T5)*

## Discussion

The presumed conflict between religion and evolution is considered one of the main causes for rejection of evolution worldwide. However, there is a unique group of religious scientists and teachers who accept evolution, and the goal of this study was to gain a better understanding of this group's conceptions of the relationship between evolution and religion, and the factors that influenced those conceptions. The participants of this study held

two main approaches to the relationship between evolution and religion—complementary and contrast (following Yasri et al. 2013). Most of them said that their views were influenced by their families and teachers. The source of their evolution knowledge was also found to have an important influence on their acceptance of evolution. Participants who had rejected evolution in the past emphasized the importance of their exposure to the various religious sources that offer explanations for compatibility between science and religion.

### Participants' conceptions of science and religion

Since many studies show that as religiosity increases, the level of acceptance of evolution decreases (Allmon 2011), religious people who accept evolution are considered to make up a relatively small and extreme group with "low probability of occurrence" (Paz-y-Miño-C and Espinosa 2013). The research population of this study was composed of religious scientists and biology teachers with a high average total MATE score (88.05). This finding confirmed that the population chosen for the study fit the predetermined requirements for the study population in terms of religiosity and high acceptance of evolution.

Relating to the participants' conceptions of religion, almost all of them said that the scriptures are not meant to teach science or history and that they do not believe in a literal interpretation of the creation story. Almost all the interviewees quoted commentators and rabbis who talked about the complexity of the creation story and the moral values that can be learned from it. It may be concluded that the conception of the scriptures as a spiritual and moral guide and not as explaining or describing reality, as history and science try to do, is an important component in accepting evolution for a religious person. This finding may offer an explanation to the previously presented studies that found Jewish scientists are accepting science and evolution more than the general population (Dunk and Wiles 2022; Ecklund and Schitle 2014), maybe as a result of the common idea that the scriptures should not necessarily read literally. Usually, those who believe that there is a conflict between evolution and religion—regardless of whether they are religious, secular, or traditional—believe that the creation story should be understood literally. It has been previously suggested that objection to science is due to a simplistic literal comprehension of the bible (Dodick et al. 2010). Therefore, mentioning that there are different theological explanations for the creation story may help promote the understanding that religion and science can be compatible, in order to help students with a religious affinity study evolution with no conflict.

Relying on sources of authority was offered by the participants as one of the fundamentals of every society

(Graham et al. 2009). Specifically, religious Jewish people tend to rely on rabbinical sources of authority for all life aspects, as this is one of the common ideas of Judaism (“Assume for yourself a Rabbi” is mentioned twice in *Pirkey Avot*, which is part of the Jewish didactic ethical literature). Here we found that religious sources of authority were important in shaping the participants’ views of the relationship between evolution and religion. All but one of the participants emphasized different rabbinical figures who dealt with issues such as the non-literal understanding of the scriptures (such as Rambam), or the specific issue of evolution (such as Rabbi Kook), while each participant emphasized the figures that fit his or her own world view. This finding suggests the possibility of presenting students with various rabbinical views, as some of the participants reported (data not shown), because the understanding that there are religious authorities that accept evolution may ease the students’ tension.

Among the approaches to understanding the relationship between science and religion that are described in the literature (Yasri et al. 2013), we found that the participants had two main approaches—contrast (different questions/methods) and complementary. All participants (except T10) agreed that there is a fundamental difference between the two disciplines. Most of them said it explicitly in their interviews or agreed to some extent with the contrast approach on the SRSII questionnaire. In addition, all of the participants (except T4) agreed to some extent that the two disciplines complement each other. This finding may show that both approaches can reside simultaneously in the same person. Gould’s (a non-orthodox Jew) offered this idea in his Non-Overlapping Magisteria (NOMA) principle, which divides the magisterium of science to cover “the empirical realm: what the Universe is made of (fact) and why does it work in this way (theory). The magisterium of religion extends over questions of ultimate meaning and moral value. These two magisteria do not overlap, nor do they encompass all inquiry” (Gould 1999). Dodick et al. (2010) showed that religious people do not always hold only one approach to science and religion, but may have several approaches (Dodick et al. 2010). The findings of the present study strengthen their conclusion, because most of the participants agreed with more than one approach in the SRSII questionnaire (Table 4). This suggests that religion and science can exist as two separate, and possibly complementary entities to create the reality of the participants. This comes in line with a study that found that scientists do not think science is in conflict with religion, but most of them see religion and science as operating in separate spheres (Ecklund et al. 2016).

The finding that most participants agreed with the complementary approach may indicate an interdisciplinary perspective of the issue. Nikitina (2005) suggested that hybridization of disciplinary views may ease tensions and differences between the disciplines and help bridge them. Our findings emphasize the need to discuss the relationship between religion and science, even in science class, despite the apparent need to separate them, since it enhances interdisciplinary thinking, which occurs when people attempt to actually bridge different disciplinary perspectives into an integrated whole.

A small non-significant gap was identified between the average MATE scores of participants who chose contrast (7) and those who chose complementary (13) in the SRSII questionnaire. This finding suggests a lack of preference for one or the other approach when trying to cope with the science–religion relationship, as proposed by others (Agrest 2001). It is possible that exposing students to both approaches will help them overcome the conflict between evolution and religion.

The controversy of arbitrary nature vs. divine providence was mentioned by the participants as one of the most fundamental arguments when discussing evolution and religion, because together with the scientific findings, a philosophical atheistic view is attributed to evolution (Lyons 2010). As an outcome, the conception of divine providence may seem as contradicting evolutionary theory, even though it contradicts only one philosophical interpretation of it. It is important to remember that this conception does not stem from scientific findings but is just one of several possible interpretations, as suggested by Yasri et al. (2013). That way, the participants can accept the scientific findings and the mechanisms offered by evolution, and yet retain their religious view of divine providence. An educational conclusion from this finding is the importance of discussing the nature of science with students, as previously suggested (Dunk et al. 2019). This will enable them to understand science’s roles and limitations, the differences between observations and interpretations, and the fundamental differences between science and religion.

#### **Factors that influenced the participants’ acceptance of evolution**

In the small unique population that participated in this study, no statistically significant difference was found in the average MATE scores of scientists vs. teachers, or between their various educational levels (BSc–MSc, PhD–Prof.) (Table 6). This finding can be explained by the various educational degrees in each group. We cannot draw any conclusions from this result for the general population, but it shows that in this unique population of religious and scientifically educated people, the level

of education does not affect the level of acceptance of evolution, although a positive correlation between educational level and evolution acceptance has been previously reported (Heddy and Nadelson 2012).

Most of the participants indicated that their evolutionary education was based on formal means, such as university or high-school courses. Three participants indicated that they had never learned evolution in a formal way, but mentioned informal means such as general courses, museums, books and nature films. When the average MATE scores of the two groups were compared, we found that participants who studied evolution formally had an over 20-point higher MATE score than those who studied evolution informally. The difference was statistically significant in all categories and in the total MATE score (Table 6). This finding may be also explained by one of the limitations of the MATE, as it includes a few questions that could measure evolution understanding rather than acceptance (Smith 2010). Some of the formal group interviewees mentioned that it was only when they learned evolution formally that they understood it. It is important to mention that the teachers who did not learn it by formal means differed in their educational levels—undergraduate, MEd and PhD (in science or in science teaching). This emphasizes the importance of learning evolution properly in school, since for many people, this may be their last chance to learn it in a formal way.

Most of the participants had never rejected evolution, while 6 of them had rejected evolution in the past. When the average MATE scores of these two subgroups were compared, we found that the score of the group that once rejected evolution was significantly lower than that of those who had always accepted evolution (Table 6). This finding may indicate that people who once rejected evolution will not always accept all of its aspects, even if they indicate explicitly that they now accept evolution. In contrast, participants who never rejected evolution had a very high level of acceptance, indicating that they never had any conflict with evolutionary principles.

The participants emphasized that their conception of evolution (acceptance/rejection) was influenced by their families' and teachers' positive/negative approach to science, respectively. Past research has shown the influence of family and community on students' conception of evolution (Sbeglia and Nehm 2020; Winslow et al. 2011). Because teachers can have a positive or negative influence on students' conceptions of evolution and science in general, there is a need to provide teachers with enough knowledge and tools to influence their students' conception in a positive manner.

Six participants who had rejected evolution in the past gave three main reasons for that rejection: (a) lack

of knowledge, (b) authority that emphasized the conflict, (c) social objection. These three factors may be connected, because students' lack of knowledge can result from teachers being unwilling to teach evolution due to religious opposition (Moore and Kraemer 2005; Rice et al. 2011), or instructors that teach evolution as fundamentally atheistic and even make disparaging remarks about religion during class (Barnes and Brownell 2016; Barnes et al. 2017). It has been shown that if science teachers understand the range of perceptions of the relationship between religion and science, they are more likely to help their students cope with the conflict (Reiss 2009). Moreover, it was found that when religious Christian college instructors taught evolution in a culturally competent way, it increased their students' acceptance of evolution and reduced student conflict between evolution and religion (Barnes and Brownell 2018). Therefore, a comprehensive professional development program is needed to enable teachers to deal with the students' conflicts. The social objection mentioned by the participants referred to a feeling that they were supposed to object to the idea, that it does not belong to them as religious Jews; however, they could not pinpoint the source of this feeling. Previous surveys have shown that, indeed, among religious populations, evolution is usually rejected by the majority (Pew Research Center 2016), and societal religiosity was offered as an important factor that may influence biology teachers and teaching worldwide (Silva et al. 2021).

The participants who had rejected evolution in the past indicated that exposure to scientific knowledge alone was not enough to weaken their objection, whereas exposure to various religious authorities that offered explanations of the compatibility between religion and evolution (books, lectures, courses, etc.) promoted their acceptance of evolution. Therefore, exposing students to the suggested solutions that present compatibility between religion and science may help them accept the idea that there should not be a conflict between their belief and the currently available scientific knowledge on evolution. Some studies have shown that students do not present a statistically significant increase in their acceptance of evolution scores after being taught about evolution (Short and Hawley 2015; Walter et al. 2013). The findings shown here indicate that the missing link may be exposure to the compatibility between religion and evolution. The main cause for rejection of evolution by religious people is the presumed conflict between evolution and religion (Muğaloğlu 2018), even though there are various religious explanations for the compatibility between religion and science in general, and evolution in particular (Dodick et al. 2010; Pear et al. 2015). Therefore,

as the interviewees declared, studying these theological explanations can provide solutions to the conflict and enable acceptance of evolution. Studies have found that presenting students with reconciliatory approach and compatibility between religion and evolution were important factors leading to increased students' acceptance of evolution (Ferguson and Jensen 2021; Tolman 2020). Accordingly, the exposure of students to scientific knowledge may help establish the strength of evolutionary theory, and exposure to the suggested solutions that present compatibility between religion and science, may help students accept the idea that there should not be any conflict between their belief and the currently available scientific knowledge of evolution.

To summarize, the challenges of evolution education have been discussed in many studies. Here we focused on understanding religious scientists' and teachers' conception of the relationship between evolution and religion, and exposing the factors that may have influenced that conception. The findings may help science teachers understand how to help their students settle the conflict that may arise in class. Specifically, this study's population demonstrates that settling between science and religion was possible for them. We showed that the study population held mainly two approaches toward the relationship between evolution and religion, complementary and contrast. This finding may give teachers the option of presenting students with the various approaches to the complexity of the issue (Yasri et al. 2013), while each student may prefer a different approach. The interpretation of the bible as providing moral guidance rather than being a book of science was a main idea in the participants' conception—this may emphasize the importance of discussing differences between science and religion by talking about the nature of science. The factors that may have influenced the participants' conception suggest the importance of presenting students with different religious solutions to the conflict, since we showed that understanding scientific knowledge alone did not change the participants' conception. To enhance these conclusions, professional development programs should discuss the different possible views of the relationship between science and religion. That way, teachers will be familiar with possible approaches to the controversy, and hopefully will be prepared to address the students' challenges and difficulties (Scharmann 2018; Southerland and Scharmann 2013). In addition, exposing teachers to the conceptions of this study population can contribute to understanding a model for accepting both religion and evolution, which may be important for every teacher, because we have previously shown that religiously affiliated students can even be found in secular schools (Stahi-Hitin and Yarden, 2022). Implementation of these conclusions in teacher

professional development programs may help teachers promote their religiously affiliated students toward better learning of evolution and meaningful learning of science in general.

## Appendix 1: Pre-interview questionnaire

1. What is your name?
2. What is your education?
  - a. BSc.
  - b. MSc.
  - c. PhD.
  - d. Other.
3. How old are you?
4. How do you define your level of religiosity?
  - a. Secular.
  - b. Traditional.
  - c. Religious (modern Orthodox).
  - d. Haredi (ultra-Orthodox).
  - e. Other.
5. In your opinion, on a scale of 1–5, is there a conflict between religion and evolution?  
No conflict 1 2 3 4 5 Conflict.
6. Where did you receive your evolution education? (you can choose several answers)
  - a. Academic degree.
  - b. Science class in middle school.
  - c. Biology class in high school.
  - d. Popular science books.
  - e. Movies and TV.
  - f. Media.
  - g. General courses.
  - h. Museums.
  - i. Other.
7. MATE questionnaire (Rutledge and Warden 1999).

## Appendix 2: Interviews with teachers and scientists

### Part A—Evolution and religion (teachers and scientists)

1. Please tell me about yourself (general details—role, family, residence, etc.)
2. Where did you go to school and university? Did you learn evolution there? If yes, how was the subject taught? If not, where did you learn evolution?
3. What drove you to study evolution?
4. Have you ever felt internal opposition to evolution? Can you describe what influenced you? Was there any turning point in your relation to evolution?
5. What was your family's attitude toward science?
6. Given the presumed conflict between evolution and religion, how do you reconcile your religious beliefs with evolution?
7. What do you think about different approaches of solving the conflict?
8. Is it possible to reconcile arbitrary nature and divine providence? How?

### Part B—Teaching evolution

Teachers:

1. How many years have you been teaching? Where?
2. Is it important to teach evolution? Why?
3. How do you teach evolution? (number of hours, methods, sequence in the curriculum, etc.)
4. Do you encounter opposition to evolution? If yes, can you describe how it is expressed by the students?
5. What do you think the students' opposition stems from?
6. If you encounter opposition, how do you cope with the situation? Are there ways to decrease the students' opposition?
7. Have you encountered opposition from other teachers? School administrators? Students' parents?
8. Is it appropriate to relate to religious faith when teaching evolution? If yes, how?
9. Do you relate to non-scientific issues or values at other times? in biology class?
10. Is it important that students accept evolution? Do you try to convince them?
11. Can students understand evolution without accepting it?

Scientists:

1. Have you ever thought about evolution? Where?
2. Is it important to teach evolution? Why?
3. Is it important that students accept evolution?
4. Is it appropriate to relate to religious faith when teaching evolution? If yes, how?

### Appendix 3: Coding rubric

1. Participants religious approach:

- a. The purpose of the scriptures is not to describe science or history, but to teach morals and ethics.
- b. The idea of non-literal reading of the creation story.
- c. Mentioning different rabbinical attitudes.
- d. Belief in divine providence.

2. Scientific approach:

- a. Science is the best method to understand reality in the present.
- b. Tentativeness of science.
- c. The difference between observations and interpretations.
- d. Doubt the scientific method.

3. Approach toward the relationship between science and religion: according to the classification of Yasri et al. (2013).

4. Factors that influenced the participants perception:

- a. Family.
- b. Teachers/school.

5. Reasons for past rejection of evolution:

- a. Lack of knowledge.
- b. Authority that emphasized the conflict.
- c. Social objection.

6. Factors that caused the participants to accept evolution:

a. Exposure to the compatibility between religion and science.

#### Acknowledgements

The authors would like to thank the participating teachers and scientists and Yetti Varon for assisting with the statistical analysis.

#### Author contributions

The first author conducted the interviews and collected the data. Data analysis and writing of the manuscript were conducted by the first and second authors. All authors read and approved the final manuscript.

#### Funding

Not applicable.

#### Availability of data and materials

Not applicable/all of the data are in Hebrew.

#### Declarations

#### Competing interests

Not applicable.

Received: 25 February 2022 Accepted: 13 May 2022

Published online: 07 June 2022

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