The inter-relationship of Science and Religious Education in a cultural context: Teaching the origin of life

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ABSTRACT

This study explored the opinions of teachers and 14-16 year old students about the teaching of the origin of life in Science and RE. It focused on any discontinuities between students' religious or cultural backgrounds and what they are taught in school.

A mixed methodology was used: a national teacher survey and work in four case schools (teacher interviews, student questionnaires, student focus groups). The case schools represented three contexts: a Christian faith school, a non-faith school with predominantly Muslim catchment, and two non-faith, mixed catchment schools. Grounded theory guided the design and analysis.

Most Science teachers mentioned religious beliefs in their teaching of the origin of life, and most RE teachers mentioned scientific theories. However, there was little cross-departmental collaboration, raising the concern of inaccurate teaching of science theories in RE and potentially insensitive, counter-productive treatment of religious students in Science. Students tended to perceive Science as based on fact and closed to questioning or discussion of their concerns whereas RE had a more interactive pedagogy, encouraging challenge and the expression of opinion.

Two complementary frameworks were developed from the data. One is a taxonomy of the different ways science and religion are seen to inter-relate. The other, which has been set in the context of the cross-cultural border crossing literature, reflects the propensity to engage with the science/religion interface as exemplified by the topic of the origin of life. Many Muslim students resisted engagement because of conflicting religious beliefs.

Teachers did not always appreciate the extent to which this topic troubled some students who needed help to accommodate clashes between science and their religious beliefs. Building up cross-curricular working may increase teacher knowledge and confidence as well as providing better support for students.

The engagement typology could be used to develop a simple questionnaire to enable teachers to assess student responsiveness before tackling potentially sensitive or controversial topics.

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AUTHOR'S DECLARATION

I hereby declare that the work contained in this thesis is my own and has not previously been published, with the exception of the following:

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1. Introduction

It is recognised that certain groups – literalist Christians and some Muslims, for example – have worldviews that cannot be reconciled with particular scientific ideas. As the English secondary science curriculum shifts its emphasis from facts and knowledge to a consideration of the nature of science and how the scientific community operates, the characteristics of science as a school subject are changing. At a time of widespread concern about the low numbers of students choosing to study science beyond the age of 16, might one barrier be a perceived incompatibility with religious beliefs? Darwin's theory of how life evolved through natural selection challenges aspects of various religious beliefs, including the individual creation of each species and the unique position of human beings (Poole, 1990; McGrath, 1999).

By the time they leave secondary school, most students will have come across evolution in more than one subject, principally Science and Religious Education (RE). Do they experience tensions between scientific and religious explanations at school? Are there any inconsistencies between what they are taught at school and their religious or cultural perspectives? If so, how do they cope with these?

This opening chapter explains why I considered the topic important enough to constitute the basis of my PhD. It outlines the rationale and nature of the study, and describes the chapter layout of the written thesis.

1.1 Why this topic?

The impetus for exploring the interface between science and religion in an educational context came from two opposing directions:

- a possible barrier: can religious beliefs prevent engagement with science? If so, how might the two be reconciled? Generating a sufficient supply of students to take up science-related jobs is a vital contributory factor to a healthy economy (Roberts, 2002; Sainsbury, 2007). With the continuing concern (both in the UK and more widely) that fewer students are choosing to follow science post-16 (Osborne & Dillon, 2008; van Langen & Dekkers, 2005), it is important to look at all the factors that might be contributing to this shortfall.
- a possible opportunity: the secondary curriculum encourages schools to make links between subjects. Science and RE are both integral to the curriculum from the beginning of primary school to the age of at least 16. One of the seven cross-curriculum dimensions listed in the QCA's planning guide for schools (QCA, 2009) is "identity and cultural diversity". As part of this, schools are urged to provide opportunities to "discuss and question a range of

opinions, values and beliefs" and "communicate with people of different beliefs and faiths" (p. 11). A topic with scientific and religious elements could make a major contribution to fulfilling such requirements.

It was necessary to identify a focus for this study from several topics in Science and RE that fitted the criteria of being cross-curricular and potentially provoking controversy with a religious dimension. Among them were environmental issues, embryonic stem cell research, cloning and genetic testing. The origin of life was chosen over these other options because it represented an example of scientific theory being rejected primarily for reasons of religious belief. The other issues raise ethical or social concerns that can be held irrespective of religious persuasion, but the main challenge to acceptance of Darwin's theory is a belief that species were created or designed by a supernatural being.

My choice was also informed by the central role of evolutionary theory in biology: Darwin's ideas about natural selection have been described as "among the most powerful and significant pieces of knowledge we possess" (Millar & Osborne, 1998, p. 2013). The impact of his theory was considerable: it has been described as a new worldview (Matthews, 2009) and a new paradigm (Dagher & BouJaoude, 1997). Although the idea of evolution (species gradually changing over time) had been around for many years, the suggestion that the process was driven by natural selection (organisms with successful adaptations being more likely to survive, reproduce and pass traits on to the next generation) was new (Dobzhansky, 1964; Southgate, Negus & Robinson, 2005).

Students will approach the topic with a mix of religious, non-religious and anti-religious viewpoints, held with a range of degrees of certainty. If it is true, as Dobzhansky (1964) maintains, that "nothing makes sense in biology except in the light of evolution" (p. 449), failure to engage with the theory can have serious implications for potential scientists. As the 2006 report on science education from the TLRP (Teaching and Learning Research Programme) concluded, "Much more must be found out about how the [gender and] cultural backgrounds of students interact with their learning of science in school. Unless these can be brought into harmony, it is very likely that science that will continue to be rejected by many with disadvantages for students and for the UK economy." (p. 15).

1.2 Why now?

There are signs that the theory of evolution, traditionally a divisive educational topic in the United States (US), has recently become more contentious in the United Kingdom (UK). It is reported that groups (such as Muslims and evangelical Christians) that struggle to reconcile some scientific and religious ideas are on the rise in the UK school population (Reiss, 2008a). Another factor is that changes in government policy over the last few years have enabled the sponsorship of secondary schools in England by faith groups or business people with a religious ethos. In early 2002, there was a furore when it was alleged that one of these institutions was teaching creationism (the belief that species appeared in their fully-formed state in a sudden act of “special creation”) alongside evolution in science classes (Allgaier & Holliman, 2006).

More recently, intelligent design theory, a new challenge to the theory of evolution, has spread to the UK from the US. Its thesis is that certain features of living organisms are of such complexity that an intelligent cause, rather than the process of natural selection, must have produced them (Behe, 2006). The movement does not explicitly cite God or a divine being as the power behind life on earth and it emphasises the scientific credentials of some of its high profile adherents. Nevertheless, critics are sceptical about these attempts to distance itself from religion and especially the creationist position. In 2006, an organisation called Truth in Science distributed a resource pack to heads of Science in all UK secondary schools and sixth form colleges, arguing for the intelligent design line of thinking. It followed this up in December, 2009 by sending a book entitled “Explore evolution” to libraries in all those schools and colleges teaching Biology A level (Truth in Science, n.d.).

The relationship between science and religion has a long history. According to Smith (1998), the advent of scientific thought can be traced back to the seventeenth century. Before then, Western knowledge was based on theological interpretations of the world. Adoption of the scientific method meant faith was replaced by reason as the most widely accepted basis for establishing truths, and this transformation reached fulfilment during the Enlightenment of the eighteenth century, with secular thinkers daring to challenge the previously unassailable religious leaders (Porter, 2001).

Religious thinking remained influential, however, and consequently had a bearing on the development and reception of Darwin’s theory of evolution by natural selection in the mid 1800s. Although the fixity of species had already been questioned by explanations such as Lamarck’s theory of the inheritance of acquired characteristics, there was still resistance to the idea of evolutionary change. Darwin’s ideas proved controversial, the mechanism of natural selection being interpreted as casting the role of God as creator into doubt. It has since become the most commonly accepted explanation for the development of life, both among UK scientists and the general public.

This is in stark contrast to the US, where the teaching of the theory of evolution has caused fierce disputes across the years, culminating in contentious legislation and several high profile court cases (Moore, 2007; Padian, 2009). In certain parts of the country, evolution has never been allowed to settle comfortably into the curriculum, and lately the rise of the religious right and of the intelligent design movement has reignited the issue.

There have been calls from the intelligent design community to “teach the controversy” about evolution, and vocal resistance from pro-evolutionists on the grounds that, within the context of science (rather than religion), evolution is not disputed. As a consequence, in the opinion of Darwinians such as Scott and Branch (2003), there is no controversy to teach.

There are signs that it is becoming a more hotly debated issue in the UK as well, with the media helping to ignite passions with provocative headlines such as *Ofsted OK creationism in college* (Curtis, 2002) and *Creationism question in ‘misleading’ science GCSE* (Paton, 2009).

There has also been a considerable amount written in the academic literature about this topic. However, what exists tends to be long on opinion and short on evidence. Furthermore, a large proportion of the coverage focuses on the United States and is limited to the Christian context.

This research study was designed to look at various inter-relationships: between Science and RE; students and their teachers; and the contexts of school and home. There are two main gaps in the data that it seeks to address:

- the interaction of Science and RE teaching. (The dominance of American literature has perhaps led to this being under-researched: in the US, religion is a topic generally avoided in schools through fear of falling foul of the first amendment which stipulates the separation of church and state).
- the experience of Muslim students in societies where they form a minority. (Western literature usually has a Christian focus and where the experiences of Muslims have been addressed, it tends to be in countries where Islam is the main religion (eg Edis, 2009; Hameed, 2008). The lack of such research, and its importance in a multicultural, multi-religious society, has been acknowledged by scholars including Gould (1999) and Nord (1999)).

This study aimed to provide an insight into how this topic was really being handled in schools, and to give a voice to students and their teachers.

1.3 Why me?

Like many people, I spent a long time agonising over the topic for my PhD, seizing an idea with enthusiasm one day only to cast it aside the next. On a long train journey, as we discussed possible themes, my prospective supervisor mentioned that a year of Darwin celebrations was approaching to mark the bicentenary of his birth and the 150 year anniversary of “On the Origin of the Species” being published. An idea took hold. As a first year undergraduate many years previously, I had written a dissertation on how Darwin’s ideas were received at the time of publication: why not bring that up to date in some way? Why not link it to the controversy about teaching creationism in the classroom? Media reports and publications suggested proponents and opponents of evolution find it difficult to engage in constructive debate: how then do adolescents respond? Is it a problematic issue for them and, if so, how do they cope?

My professional involvement in two particular research projects strengthened my resolve to focus on this issue. One was an evaluation of the twenty-first century science GCSE, a course designed to produce scientifically literate citizens who appreciate how science, and scientists, operate as well as understanding key scientific explanations. Study of Darwin’s theory of evolution seemed to embody the integration of these two aspects of scientific learning. The second project was carried out for the Wellcome Trust to inform their plans for the Darwin celebrations in 2009. In focus groups, some Science teachers mentioned that it was not unusual for them to be stereotyped as atheists simply because of the subject they taught. There were accounts of students (especially Jehovah’s Witnesses and Muslims) rejecting Darwin’s theory on religious grounds.

As well as the professional context, I felt that my personal background fitted well with understanding the complexities of this study. I have explored various forms of Christianity, including evangelical, Roman Catholic and Quaker, and also Buddhism. This has given me an appreciation of different religious traditions. My educational background (an undergraduate degree in Zoology and Psychology) means that I have a good understanding of evolutionary theory and natural selection.

Although this study was carefully designed to explore perceptions and not to challenge any viewpoints or beliefs, the literature stresses the importance of taking into account the researcher’s own attitudes towards the issue (Denzin & Lincoln, 2005; Patton, 2002). In terms of faith, I would describe myself as a non-believer in terms of a personal God, and agnostic about the existence of any supernatural force. My scientific view is that evolution by natural selection is the best theory currently available to explain the diversity of life we have on earth. If required to answer the question in my own survey about human life

(Appendix 1.4), I would choose the option *"Human beings have developed over millions of years from simpler forms of life. No divine being had a part in this process"*.

1.4 Research strategy and focus

The key research questions were:

1. What are Science and RE teachers' opinions about teaching scientific and religious explanations of the origin of life?
2. What are students' opinions about the scientific and religious explanations of the origin of life?
3. What are the differences, if any, between how the origin of life is dealt with in Science and RE classrooms?
4. Are there differences between students' own religious or cultural beliefs about the origin of life and what they are taught in school? If so, how do they accommodate these?

Mixed methods were used to tackle these questions, combining a survey of Science and RE teachers in England with a more in-depth study of four case schools. The latter comprised teacher interviews along with questionnaires and discussions with Key Stage 4 (KS4) students, ie those aged between 14 and 16. A grounded theory approach to methodology and analysis was followed.

The phrase "origin of life" is used throughout this thesis. It was adopted as an umbrella term for participants' responses in relation to "how life on earth as we know it today came into being". This means its use is broader and looser than a strict scientific interpretation would be. It covers concepts including creationism and evolution and also, somewhat unexpectedly, included references to cosmological origins and the big bang theory.

The study seeks to add to the existing body of research into the topic by emphasising the student voice; examining the contexts of both school Science and RE; and paying attention to the interplay between school input and personal beliefs and culture. The focus is on attitudes and perceptions and no judgements are made on the validity or otherwise of the religious beliefs and scientific theories involved.

1.5 Chapter layout

This chapter has provided a brief overview of the motivations for the study, the nature of the issue and the research questions. The following four chapters examine the relevant literature. In keeping with the use of an approach based on grounded theory, the process of reviewing the literature was an ongoing one, engaged in before, during and after the fieldwork and analysis. As a consequence, although it is presented in a linear way in the write-up of this thesis, sections were completed or extended at different phases of the process to inform the development of emerging hypotheses.

After looking at the main pertinent explanations for the origin of life, Chapter 2 compares and contrasts science and religion as ways of knowing, and examines existing models for how they inter-relate. The following chapter provides an international perspective on the teaching of evolution before focusing on the detail in the UK. Coverage of the topic in GCSE specifications and textbooks is examined. Chapter 4 summarises existing data on opinion about the origin of life from different perspectives: the general public, religious bodies, scientists and teachers. Chapter 5, which concludes the review section, explores possible ways of handling the origin of life in the classroom, including treating evolution as a controversial issue and as a means of illustrating aspects of the nature of science. The applicability of frameworks such as conceptual change theory and cross-cultural border crossings are discussed.

Chapter 6 describes the methodologies that informed this study, the methods used and why they were chosen. As well as outlining the research instruments and the approach to data collection and analysis, it explains how the pilot study influenced the main investigation. Analysis and interpretation of the findings are presented in the next three chapters (7, 8 and 9). As well as summarising the answers to the research questions, the concluding chapter looks at how the study has contributed to knowledge in this field and any resultant implications for practice and the curriculum. A discussion of the study’s strengths and limitations leads into suggestions of how the work might be built on in future.

2. Science and religion: a context

This chapter examines the literature about science and religion, in order to set the scene for the research study which will explore how students and their teachers tackle the origin of life, a topic area straddling the two fields. Firstly, it outlines the main scientific and religious explanations of the origin of life that are encountered in a Western context. It then investigates the epistemologies of science and religion and how these feed through into models of the inter-relationship between the two, finishing with specific reference to the implications for conceptualisations of the origin of life.

2.1 Main explanations for the origin of life

There are numerous accounts of how the diversity of life as it exists today has come into being. Some of these have religious or cultural roots, others emanate from a scientific base. In this thesis, three explanations are of particular relevance: evolution, creationism and intelligent design. Each of these is described in more detail below.

Charles Darwin was not the first person to put forward a theory of evolution, but (along with Alfred Russel Wallace) he was the first to suggest a mechanism for it. As early as the sixth century BC, the Greek philosopher Anaximander postulated that life had started in the sea and that humans had developed from fish (Shafer, 2003). The French naturalist Buffon is often cited as a key figure in the development of evolutionary theory as he accepted that there could be change within species over time, although his championing of the immutability of species made it impossible to call him an evolutionist (Mayr, 1982). In the late 1700s, Charles Darwin's own grandfather (Erasmus) suggested that all organic life had developed from a common ancestor, "one living filament", although this was based mainly on conjecture (Darwin, 1809).

By this time, observations of nature had begun to cast doubt on the predominant theological belief that species were individually designed by God. Study of the fossil record had revealed that it contained species which no longer existed, and theories were developed to explain this phenomenon. One suggestion was progressive replacement, championed by Cuvier. However, like Buffon, he believed in the immutability of species, maintaining that extinction was compensated for by repopulation, with more advanced species coming either from elsewhere or by acts of "special creation" (Southgate et al., 2005). Although these acts could be seen as being in harmony with contemporaneous religious beliefs, there was a reluctance to accept that God would allow any of his creations to die out (Prothero, 2006). Another proposal was transmutation, most notably Lamarck's theory of inheritance of acquired characteristics. He suggested that, far from being static, species acquired advantageous adaptations during their own lifetime and passed these on to their offspring. They had an innate capacity for self-improvement. For example, a giraffe that reached for leaves on tall trees would gradually stretch its neck and have offspring with longer necks (Southgate et al., 2005). Similarly, disuse would cause the structure to shrink and eventually disappear.

Despite these forerunners, there was still considerable resistance to the concept of evolution in the mid nineteenth century (Bowler, 2003). Indeed, it has been suggested that the hostile response to an anonymous pro-evolutionary publication in 1844 was partly responsible for Darwin waiting a further 15 years before publishing his own work (Ruse, 2000; Southgate et al., 2005). The new concept in Darwin's theory was not evolution itself - which he termed "descent with modification" (Southgate et al., 2005) - but the idea that it was driven by natural selection. He stated that organisms which are more suited to their environment have greater survival rates and reproductive success than their competitors. Because their offspring vary slightly from each other and from their parents, characteristics can be passed on from generation to generation allowing those that are better adapted to survive at the expense of those who are "less fit". Darwin was prompted into making his ideas about natural selection public when he learnt that another naturalist, Alfred Russel Wallace, had reached similar conclusions (Ruse, 2000).

Within the Western scientific community, although there is some debate about the precise mechanisms involved (eg Gould, 1999; Margulis, 1991), evolution is now generally accepted as the most convincing explanation of the origin of species (Council of Europe, 2007; DCSF, 2007). Supporting evidence has emerged from several different disciplines, including palaeontology, genetics, comparative anatomy, cellular and molecular biology, and embryology.

Traditionally, the main challenge to evolutionary theory in Western society has come from those followers of Abrahamic religions (Christianity, Judaism, Islam) who believe in creationism – that all living things were created by God and have changed little since (Peker, Comert & Kence, 2009). It is possible to believe that God created life without being a creationist: creationists are those who reject the possibility of all species having a common ancestor (Reiss, 2009). They hold closely to the accounts in their sacred texts which describe God (often referred to as Yahweh in Judaism and Allah in Islam) creating the world in six days:

> "In the beginning God created the heaven and the earth … And God said, Let the earth bring forth grass … and God created great whales, and every living creature that moveth … And God said, let us make man in our image, after our likeness." (Genesis 1:1-26 King James Version)

> "Allah created the heavens and the earth, and all that is between them, in six days." (Qur'an 7:54)

The interpretation of "day" varies. In the Qur'an for instance, the Arabic word "youm" (day) has an elastic definition. It is used for substantial but variable lengths of time ranging up to 50,000 years. For this reason, Muslims seldom have difficulty accepting modern geological estimates of the age of the earth. However, many biblical literalists in the Christian tradition interpret a day as 24 hours and consequently believe that the earth is 6-10 000 years old (Scott, 2009).

Intelligent design proponents maintain that some aspects of life are so complex that they must be a result of deliberate design rather than evolution by natural selection (Colburn & Henriques, 2006). Behe (2006), one of its most prominent advocates, accepts the idea of a common ancestor and an ancient earth. However, he argues that Darwinism cannot explain the large jumps found between species nor the level of complexity within many organisms: he rejects natural selection as an explanation for molecular life. In his book, Behe emphasises his scientific credentials and includes an appendix on biochemistry. Across the intelligent design movement as a whole, these references to science are combined with a vagueness about the identity of the outside agent responsible for the "intelligent design" (Ruse, 2000). Among evolutionists, there is a widespread conviction that intelligent design is simply a new, more subtle, incarnation of anti-Darwinian religious stances and it has been referred to as "the new creationism" (Pennock, 1999; Young & Edis, 2004).

Scott (2009) has questioned the tendency to divide attitudes towards the origin of life into two camps: creationists or evolutionists. She proposes instead a spectrum of views, running from adherents of the literal scriptural account of the universe with life being created by God in six days, to those who accept the scientific theory and deny the existence of a supernatural dimension. A simplified form of her schema (which relates to a biblical and therefore implicitly Christian perspective) is presented in Figure 2.1. Intelligent design is shown on the vertical axis, as its different adherents hold a range of positions concerning the geological age of the earth.

Figure 2.1: The evolution/creationism continuum in a Christian context

(from Scott, 2009: simplified and annotated)

CREATION

Young-earth creationism *(God created the universe and all life in approximately its current form)*

Young Earth *(earth is 6-10,000 years old)*

Old Earth *(accept most modern physics and geology)*

Gap creationism *(original creation destroyed; God re-created life in 6, 24 hour days)*

Day age creationism *(each of the 6 days was a long period of time)*

Progressive creationism *(God created different "kinds" of animal sequentially, as shown in the fossil record, and evolution within "kind", eg the cat family, could occur)*

Evolutionary creationism/theistic evolution *(God creates through evolution)*

Agnostic evolutionism *(accept evolution; don't completely rule out a god)*

Materialist evolutionism *(evolution by natural causes; no supernatural forces exist)*

Intelligent design creationism *(some phenomena are too complex to have evolved gradually, so must have been specially designed)*

EVOLUTION

2.2 Science and religion as ways of knowing

Before discussing models of how science and religion might inter-relate, it is important to establish how each of them is defined to ascertain whether there is a consensus about what they comprise and if so, what that is. Alternatively, if there is a range of opinion, how broad is that variation? No definitions are unambiguous and uncontested, and the wide range of sciences and religious beliefs complicates matters even further.

2.2.1 Science as a way of knowing

Although, as acknowledged above, it is difficult to achieve unanimity on what science comprises, there are some areas of broad agreement. Firstly, in terms of its sphere of operation, science is seen as dealing with the natural world - what it is made of and how it works (Carvalho, 2006; Lederman, 2006; McComas, Clough & Almazroa, 1998; Poole, 2007). Moral and ethical considerations are judged to be outside its sphere: in the words of Reiss (2009), science pertains to “how things are rather than ... how they should be” (p. 1935). There are also certain elements of its mode of operation that are agreed to be characteristic. Theories are testable, being based on empirical evidence that has been collected objectively and transparently, thus allowing findings to be reviewed and procedures to be repeated by other scientists. Because it is open to test and challenge, the resultant knowledge is tentative and scientific theories are falsifiable – subject to change if the evidence indicates re-assessment is necessary (McComas et al., 1998; Orr, 2006).

These attributes are summed up in the definition of science produced by the Science Council (a membership organisation for professional science-related bodies across the UK): “the pursuit of knowledge and understanding of the natural and social world following a systematic methodology based on evidence” (Science Council, 2009). Similarly, science for Wallace (2006) is an organised and systematic approach which “gathers knowledge about the world and condenses that knowledge into testable laws and principles” (p. 25). Merton (1973) describes science as willing to consider new ideas, universally applicable, impartial and communal (in the sense that, even if a scientist works alone, the knowledge produced must be accepted by the scientific community as a whole).

According to Wallace and Louden (2002), we are in a revolutionary period for understanding the nature of science. They identify a shift from the portrayal of science as objective and value neutral, guided by reason and empirical evidence, to its conceptualisation as an undertaking far more subject to human influence than previously acknowledged. It is increasingly recognised as being influenced by the society and culture of the time and place (McComas et al., 1998).

Table 2.1 summarises the main elements of the nature of science extracted from three key sources. It shows that all three accounts describe science as empirically-based, scientific knowledge as tentative and observations as subject to some level of personal or theoretical influence. Features common to two out of the three descriptions include its basis in the natural rather than supernatural world; the production of transparent and replicable findings; and its basis in social and cultural practices.

Table 2.1: Descriptions of the nature of science

McComas et al (1998)	**Lederman (2006)**	**Ruse (1981)[1]**
observation, experimental evidence, rational arguments, and scepticism.	empirically based	empirically testable
tentative	tentative	tentative
observations are theory-laden	subjective (personal biases/theory laden)	objective but personal biases
an attempt to explain natural phenomena		explanatory according to natural law
laws and theories are distinct	laws and theories are distinct	
must be reported clearly and openly		public
accurate record keeping, peer review and replicability		repeatable
scientists are creative	creative	
part of social and cultural traditions	socially/culturally embedded	

[1] From McLean v. Arkansas Documentation Project, n.d.

The scientific nature of Darwin's theory can be exemplified by reference to this table. For instance, it is concerned with the natural rather than supernatural world; supporting evidence is found in the fossil record and comparative anatomy; and Darwin developed the theory as a result of meticulous recording of data and a lengthy process of detailed and creative thinking.

2.2.2 Religion as a way of knowing

The literature suggests that it is more problematic to agree a definition for religion than for science. Spilka, Hood, Hunsberger and Gorsuch (2003) cite scholars from fields including sociology, psychology and anthropology who have been unable to define religion or have avoided doing so.

According to Pargament (1997), there are two views about what makes religion distinctive: the substantive and the functional. The substantive tradition defines the supernatural as the key element. It concerns God and higher beings. Other authors also recognise that most religions maintain that there is more to reality than the objective world and therefore deal at least to some extent with the realm of the supernatural (McGrath, 1999; Reiss, 2009). Stark and Bainbridge (1985) cite a minority who maintain that the term religion should cover wholly naturalistic philosophies such as Marxism, but they contest such definitions.

The functional tradition (Pargament, 1997) focuses on how religion tackles the "ultimate" questions (those about matters of existence). Religion is often defined with reference to a search for a meaning and purpose to life (Gilkey, 1985; Tillich, 1962). For Wallace (2006) it is commonly described as "addressing questions concerning the meaning and purpose of life, our ultimate origins and destiny, and the experiences of our inner life" (pp. 25).

Because the substantive definition relates to the nature of belief rather than how it works it is quite static. The functional definition, dealing as it does with how belief is put into action, is more dynamic. Pargament (1997) concludes that religion embraces both aspects.

There is a focus on the individual in religion (Peacocke, 1971). Behaviour, beliefs and personal experiences all contribute to people's religious lives (Spilka et al., 2003), and these aspects are not always amenable to empirical measurement (Cavallo & McCall, 2008). As a consequence, the logical positivists of the 1920s dismissed religion as worthless because it was not scientifically provable (Poole, 1990). However, there are a number of areas where religion has been subjected to scientific scrutiny, exploring for instance the outcomes of prayer or impact of meditation (Reiss, 2009).

Religion has been characterised as being based on "unquestioning certainties" (Wolpert, 1993). But, like science, it is socially embedded and its nature may change over time

(Guthrie, 1996). Orr (2006) differentiates a *non*-scientific from an *un*-scientific form of faith. The former goes beyond knowledge based on reason, as found in natural theology, and might be equated instead with revealed religion (which is rooted in religious experience and scripture). It cannot be falsified because it is not testable in a recognised, scientific way. Un-scientific faith, rather than going beyond the evidence, is actually at odds with it – what Orr terms “blind faith”. Not only is it falsifiable but it has been falsified. For example, young earth creationism is directly contradicted by modern geological and cosmological estimates of the age of the earth.

The three main religious traditions in the Western world are Christianity, Judaism and Islam. There are many differences of belief and practice both between and within the religions, but they share some important commonalities. They are all examples of theism – the belief in an omnipotent being who created and maintains the world. They have faith in this creator who, although called by different names, is essentially the same being across the three religions. Furthermore, all three trace a common ancestry back to Abraham.

For each religion, truth is revealed through God’s word (the Torah and Talmud in Judaism, the Old and New Testaments of the Bible in Christianity, and the Qur’an in Islam). Within and between the religions, there are many differences in interpretation of God’s word and the level of adherence to it.

2.2.3 Comparison of science and religion as ways of knowing

Before comparing science and religion as entities, it is useful to explore the historical background. Whereas there is evidence from cave paintings and burial sites that religion of some form was around in the later Palaeolithic period (Lieberman, 1991; Wunn, 2000), the modern Western scientific method only started to emerge at the beginning of the seventeenth century (Smith, 1998). This was the time of the Enlightenment when Francis Bacon (among others) wrote about using experiment and observation to determine the truth rather than relying on revealed truth. As an approach it was seen as threatening the dominant theological ways of understanding, and it created the potential for scientists being denounced as heretics. The case of Galileo provides an illustration of this. His heliocentric position clashed with the insistence of the Roman Catholic Inquisition that the earth was at the centre of the universe, and he had to disown it to save his life (Smith, 1998). However, scientific thought gained ground in the West and according to Stanesby (1985), by the late nineteenth century many theologians recognised the scientific method as a valid way of establishing reliable knowledge.

There are several differences that are generally acknowledged between science and religion. One is the realm of operation: as discussed above, science is restricted mainly to the natural world whereas religion has a large supernatural element. Science is based on empirical evidence obtained in a transparent way that makes it repeatable. In contrast, individual experience plays a key part in religion, and this is usually very personal and cannot be scientifically tested or replicated. Evolutionary biologist Jerry Coyne is cited (Waldrop, 2011) as saying "religion is based on dogma and belief, whereas science is based on doubt and questioning" (p. 325).

However, it has been argued that science need not be confined to the natural world provided a scientific means of testing can be constructed. Fishman (2009) makes the point that supernatural phenomena have been explored scientifically, citing a double-blind test of the power of prayer.

Many authors present the differences simply as matters of degree rather than type. Barbour (1990) identifies a number of common links in the ways science and religion operate, such as the interaction of data and theory and the influence of history on interpretation. He lists four main assessment criteria for both scientific theories and religious beliefs, although they are applied differently in the two cases. These are agreement with the data (the data being religious experience, story and ritual in the case of religion); coherence (consistency with other theories or accepted beliefs); scope (how broadly applicable they are); and fertility (do they suggest new hypotheses or experiments in the case of science; or have effects on the human character or implications for urgent issues such as nuclear war in the case of religious belief). Barbour acknowledges that science tends to be more objective, rational, universal and tentative whereas there is more emphasis on subjectivity, personal judgement, historical conditioning and commitment in religion.

Peacocke (1971) also makes the case for science and religion being comparable undertakings, and deliberately seeks out similarities. For instance, he challenges the perception of science as changing and Christianity as static. He argues that there are new theologies and moralities, whereas new scientific theories are often built on old ones. Scientists have shown resistance to the new, for example theories of Darwinian evolution and relativity.

Other authors stress instead the differences between science and religion. Staver (2010) sees them as having different foci (the natural and supernatural world respectively), although he identifies similarities in the way they operate through scientific inquiry and theology. Stephen Jay Gould (1999) differentiates the two based both on sphere of activity and method of operation but he does not consider them to be in conflict. For him, science is the empirical exploration of the basis and workings of the universe, whilst religion investigates ultimate meaning and moral value. He coined the term “non-overlapping magesteria" (NOMA) for these two separate enterprises which he described as "entirely different, and equally vital, subjects" (p. 3). In contrast, Richard Dawkins sees the two as frequently addressing the same subject matter and he discounts religion as a completely unscientific pursuit (see, for example, Dawkins, 2007). Likewise, the physicist Stephen Hawking questions the epistemological basis of religious pronouncements. He recently claimed in a television interview "there is a fundamental difference between religion, which is based on authority, and science, which is based on observation and reason. Science will win because it works" (Heussner, 2010).

Others might not agree that the differences are quite so clear-cut. On the issue of authority, for instance, Kuhn (1996) declares that "science students accept theories on the authority of teacher and text, not because of evidence" (p 80). In a similar vein, Smith and Scharmann (1999) draw attention to the correlation between the attention given to scientific pronouncements and the renown of the scientist making them. Not only do Smith and Scharmann find it difficult to isolate what properties characterise science, they also consider it to be needlessly controversial. They suggest instead putting the contested definitions aside and focusing on the degree to which a field can claim to be scientific. They identify three criteria of measurement: the importance of quality of experiment rather than authority; objectivity versus subjectivity; and degree of falsifiability or testability.

The Austrian philosopher Paul Feyerabend (1999) argues that science abuses its position in society by presenting itself as superior to other ideologies such as religion. He maintains that it has rested unjustifiably on its reputation as a liberating force established during the time of the Enlightenment and that it may now have become repressive. Nor can it claim to have a monopoly on truth: "*Science is just one of the many ideologies that propel society and it should be treated as such*" (p. 187, italics in the original).

2.3 Inter-relationship of science and religion

This section considers the different ways of conceptualising the relationship between science and religion, and how this relates to perceptions of each as ways of knowing.

Academic interest in the inter-relationship of science and religion is growing and it has spawned a large body of literature (Anderson, 2007; Bausor & Poole, 2002; Jones & Reiss, 2007). This includes three peer-reviewed quarterly journals: Zygon; Science and Christian Belief; and Theology and Science. Other journals have published special issues dedicated to the theme of science and religion, including Science and Education (2009) and Cultural Studies of Science Education (2010).

There are divergent views about how the relationship has been portrayed in the past, and the accuracy of such descriptions. According to Poole (1990), for example, science and religion existed in harmony until the second half of the nineteenth century, when disputes arose about the origin of species and the age of the earth. On the other hand, Bertrand Russell (1935) refers to the "history of the warfare waged by traditional religion against scientific knowledge" (p. 7). Brooke (2006) ascribes the lack of consensus about the nature of the relationship to the multiplicity of sciences and religions encompassed by the two terms which makes it impossible to develop a single, coherent model of how the two interconnect.

Mindful of the difficulties, this section examines some of the different theoretical models that have been devised to explain the inter-relationships of science and religion. Because the study reported here uses grounded theory, none of these models will be imposed on the data (Section 6.7.1). They will however be revisited during the discussion of the findings to explore how they relate to any theoretical framework that arises from the data.

Barbour's classification is perhaps the best-known and most widely-cited of all the proposed models (Anderson, 2007; Bausor & Poole, 2002; Jones & Reiss, 2007; Reiss, 2009; Southgate & Poole, 2005; Stolberg, 2009). Over the years, he has developed and refined his four-fold taxonomy as follows (Barbour 1990, 2000):

- conflict: science and religion are in opposition, with just one of them being valid. Dawkins (1999) adopts this position, arguing that religious faith is based on belief without evidence, leaving science as the only convincing path to knowledge.
- independence: science and religion are different endeavours - science is how and religion is why. This is exemplified by Gould's concept of NOMA (Gould, 1999).
- dialogue: science and religion are related through similar questions and methodologies. This is the stance that God made the universe intelligible so that scientists can explore it and better understand the workings of his mind. It describes the position taken by the Christian scientist John Polkinghorne (2005).
- integration: encouraging, for instance, the search for evidence of God in nature or the reformulation of faith beliefs in the light of scientific developments. This describes the Dalai Lama's view that, if a Buddhist belief is contradicted by scientific evidence, the belief should be discarded (Lama, 2005).

Barbour (2000) presents the model almost as a hierarchy, making it clear that his own preferences lie with dialogue and integration. It is, however, possible to conceptualise integration as an approach akin to "God of the gaps" with a divine cause being imputed because science is unable to furnish an explanation. Commentators such as Coulson (1953) and Peacocke (1978) have criticised this type of reasoning as self-defeating because, as scientific advances explain more elements of the natural world, God's role is gradually eroded.

Several of the other models of the inter-relationship between science and religion have parallels with Barbour. For example, Haught (1995) carves up the territory in a similar way. He too has a category called conflict and also one he terms contrast, which represents the separation enshrined in Barbour's independence. His grouping "contact" portrays science and religion as different endeavours, but impacting on each other – this combines many aspects of dialogue and integration. His fourth classification, confirmation, is a version of dialogue: religion supports and even nurtures scientific progress. Like Barbour, he admits that his sympathies are with the latter two categories that bring science and religion closer together.

Some of the models are simplified versions of Barbour. Shermer (2006), for instance, supports a three-way classification: conflicting, same, and separate worlds. Conflicting and separate worlds equate to Barbour's conflict and independence respectively. The same-worlds version envisages religion and science, or faith and reason, as two approaches to exploring the same reality, with scientific explanations fitting in with sacred texts, either literally or figuratively. Because Shermer sees science and religion as having very different concerns and methods, he personally supports the separate worlds position. Stenmark (2004) also proposes three main categories. He defines them in terms of the degree of overlap between science and religion: none (termed independence), some (contact) and complete (monism). In the latter two models, science and religion can either be in conflict or in harmony.

In Nord's classification (1999), the first two positions present the two areas as being in conflict. He gives them the self-explanatory titles "science trumps religion" and, conversely, "religion trumps science". His third position is independence, equivalent to Barbour's identically-named category and NOMA. Finally, he conflates dialogue and integration into "integration", with science and religion examining the same world but not necessarily drawing the same conclusions.

Barbour's categories have been criticised for being so wide that they lack sensitivity and are difficult to use in real life scenarios (Cantor and Kenny, 2001; Southgate & Poole, 2005). Other taxonomies have introduced sub-divisions or added further dimensions to increase discriminatory power. Peters, for instance, proposes eight categories, four of which he describes as warfare models, four as non-warfare (Peters, 2006). Unusually, he devotes an entire classification to the creationism/evolution issue, although this sits rather uneasily within the more generalist nature of the rest of his schema. The warfare positions are:

- scientism (scientific discovery is the only route to understanding the material world, which is the only form of reality)
- scientific imperialism (does not rule out a supernatural dimension but advocates its exploration by scientific rather than theological means)
- ecclesiastical authoritarianism (theological claims are superior to scientific ones)
- battle over Darwinian evolution (consisting of five positions: scientific creationism; intelligent design; theistic evolution – God works through the process; faith is not relevant; there was no divine input)

Peters' non-warfare models are:

- two-language theory (equivalent to Barbour's independence)
- hypothetical consonance (common subject matter, eg big bang and God creating out of nothing)
- ethical overlap (combining expertise to tackle areas such as genetics and ecology)
- New Age spirituality (harmonising science and religion)

Peters (2006) asserts that the two-languages model is currently the most popular view, with science being equated to the language of facts and religion the language of values.

Drees (1996) identifies different challenges to religion that have arisen due to developments in natural science and more sophisticated conceptions of history and culture – new knowledge, new views of knowledge and changed appreciation of the world. He maps these on to different views of religion (categorised by the amount of emphasis given to understanding the nature of reality as opposed to religious experiences or religious tradition). The resultant model is a three by three matrix so complex that the whole of Barbour's taxonomy fits into one of its cells.

Having these more numerous and precise definitions has been criticised by Barbour (2000) as potentially leading to a higher number of unattributable cases. More damningly for the enterprise as a whole, Glennan (2009) argues that neither science nor religion is a sufficiently cohesive concept to form a unified worldview. If this is the case, trying to place them within a rigid framework may not be practicable.

Stances on evolution and creation can be mapped on to Barbour's classification system (Barbour, 1990). The conflict category covers the two most commonly encountered positions - those of scriptural literalism (which rejects any explanation other than the one in the holy texts) and scientific materialism (which stresses that chance and natural selection have led to the complexity found in nature, and eliminates any role for a supernatural being).

Others fall into the independence category. Haury (2007), for instance, does not perceive acceptance of human evolution as automatically removing the role of a supreme being, therefore it does not necessitate choosing between a religious or a scientific explanation. However, because the existence of such a being is not something that can be tested empirically, it is not an issue that science can pronounce on. This viewpoint is tantamount to independence.

Integration embraces both intelligent design with its talk of "irreducible complexity" necessitating the hand of a designer (Behe, 2006) and the stance of Peacocke (1978) who envisages evolution as God's method of creating.

2.4 Summary

This chapter has outlined the three main scientific and religious explanations for the origin of life. It examined science and religion as ways of knowing and showed that the nature of both is contested. It is generally agreed that science deals with the natural world and questions of how not why. In recent decades, there has been increased recognition of the tentative nature of scientific knowledge: new evidence can lead to theories being re-cast. The literature around the nature of religion is less clear. Two characteristics emerge as key: it deals with matters beyond the natural world and considers ultimate questions about matters of existence, such as the meaning and purpose of life.

Some of the most influential models of the relationship between science and religion were discussed. Most are based on three possibilities: the two domains are in conflict, or entirely separate, or synergetic. How these fitted with different stances on the origin of life was discussed. Against this backdrop, the next chapter will consider how the origin of life is dealt with in the classroom.

3. Educational context

This chapter reviews the coverage of evolution and creationism in the classroom. Firstly, it considers the curricular coverage in a range of countries to provide an international perspective. There is a particular focus on the US and Turkey to provide a historical and contemporary dimension based on countries with Christian and Muslim majority populations respectively. The exploration then moves on to England and the relevant parts of the English curriculum and accompanying textbooks are outlined in more detail.

3.1 International perspective

Much of the literature gives the impression that the debate over the teaching of evolution is primarily confined to the US. For instance, Shermer (2006) claims that “evolution is controversial only in America” with “a few small creationist pockets in Australia, NZ and the UK” (p. xviii). Likewise, for Gould (1999) “this controversy is as locally and distinctively American as apple pie and Uncle Sam” (p. 129).

However, in many countries the issue has proved contentious since Darwin’s era and recently the controversy seems to have become both more widespread and more heated. This is indicated by the decision of the Council of Europe (Europe’s main human rights body) to produce a report describing the creationist challenge in 14 of its member countries (Lengagne, 2007). There has been growing concern about treatment of the issue in Islamic communities. This led Canada’s McGill university to hold a symposium in March 2009 which explored how evolution is taught to Muslim students in various countries (from Canada to Turkey and Pakistan) and how evolutionary science is understood in the context of Islamic beliefs (McGill symposium, 2009).

There is a temptation to classify countries by the nature and strength of their religious character when exploring their approach to teaching evolutionary theory, but this is an over-simplification. Historical background (eg a post-colonial rejection of Darwin as a Western scientist) as well as socio-political circumstances play an important role (Burton, 2011). Furthermore, organisations with an Islamist viewpoint that advocate alternatives to evolutionary theory are often closely linked with Christian creationist bodies despite their different religious underpinnings (Edis, 1999; Lengagne, 2007; Riexinger, 2008).

The remainder of this section gives a flavour of how the teaching of evolution is tackled globally. The situation in the US and Turkey, as exemplars of countries representing a Christian and Islamic majority population respectively, is examined in some detail. Their experiences are then set against a broader international picture.

3.1.1 US: A Christian perspective

The issue of teaching evolutionary theory has been controversial in the US for decades as a result of a vocal group of literalist Christians in the population. Consequently, religious, educational and legislative bodies have adopted positions that often influence organisations in other countries. The First Amendment is fundamental to how the origin of life is taught in the United States. This part of the Bill of Rights relates to the establishment of religion and freedom of religious expression, as well as other freedoms. It prevents government use of public schools (the equivalent of state schools in the UK) to establish or endorse a particular religious tradition. The separation of state and religion in the US means that the consideration of religious beliefs in science lessons is a very contentious matter. Despite this separation, Roth (2010) points out that politicians help determine the curriculum, and can introduce their own religious leanings.

Some teachers lack a solid understanding of the legal position and can be reluctant to broach religious subjects as a result (Anderson, 2007). This contrasts markedly with Europe, where divine creation is often taught in RE classes (Graebsch & Schiermeier, 2006). According to Shermer (2006), sensitivities are amplified in the southern states of the US, where a much larger proportion of society holds creationist views (51% versus 32% in the north). It is permissible to discuss religious explanations in the appropriate curricular context:

> Though science instruction may not endorse or promote religious doctrine, the account of creation found in various scriptures may be discussed in a religious studies class or in any course that considers religious explanations for the origin of life. (p. 92)

The chronological study of American biology textbooks provides a rich and illuminating source of information about trends in the acceptability of evolutionary theory in the US over more than a century. From the 1890s into the early part of the following century it featured widely in school texts (Moore, 2007) suggesting it was an unproblematic topic. This changed in the early 1920s in response to pressure from fundamentalist Christians (Grabiner & Miller, 1974). The attempted introduction of an anti-evolution bill was defeated by just one vote in Kentucky in 1922 (Halliburton, 1962). Three years later, Halliburton reports that the Butler law made it illegal in Tennessee to “teach any theory that denies the story of the Divine Creation of Man as taught in the Bible, and to teach instead that man has descended from a lower order of animal” (p. 194). Much has been written about the subsequent challenge to this legislation, popularly known as the Scopes trial (see for instance Larson, 1997 and Moore, 1998). The story also forms the basis of the famous stage play and film, *Inherit the Win*d (revived as recently as 2009 at the Old Vic in

London). John Scopes was a teacher who, by admitting he had covered evolutionary theory in his classroom, enabled the legislation to be tested in court. He was found guilty, although the verdict was quashed on a technicality. Grabiner and Miller point out that, although the case is often cited as a victory for evolutionists, the term 'evolution' subsequently disappeared from the index of US textbooks and the theory was either completely excised from the text, or downplayed to the extent that words such as ‘development’ or ‘natural selection’ replaced ‘evolution’.

In the 1950s, as a result of East/West hostilities and the space race with the USSR, the US decided they needed to produce more highly qualified scientists. The 1958 National Defense Education Act led to the funding of a raft of new textbooks (Larson, 1997). Unlike most of their predecessors, these books were written by practising scientists (Grabiner & Miller, 1974) and evolutionary concepts formed a major theme (Skoog, 2005). This caused a dilemma in states where the teaching of evolution was still effectively banned yet it featured in the recommended textbooks. In 1968, Susan Epperson, an Arkansas teacher, was prompted to challenge the anti-evolution law. She was successful and as a result, all state laws banning the teaching of evolution were overturned by 1970 (Moore, 2007).

The situation shifted again in 1980 when, as part of a campaign to win the votes of the Christian right, Presidential candidate Ronald Reagan described evolution as “only a theory” that was disputed by scientists (Padian, 2009). In the early 1990s, the state of Tennessee passed legislation restricting the teaching of evolution. Soon afterwards, Alabama introduced stickers for school textbooks which warned that they discussed “evolution, a controversial theory ...” (Borenstein, 2008). According to Borenstein, at least four other states have considered similar stickers although the one proposed for Cobb County, Georgia was outlawed by the courts because it was seen as promoting a religious viewpoint. Although it originally appealed the decision (Moore, 2007), the school board eventually signed an agreement that banned any future action that might impede the teaching of evolution (NCSE, 2007).

Moore (2007) believes that continued failures in court caused creationists to adopt intelligent design in order to challenge state educational guidelines. A movement seen by its critics as a subtler form of creationism with a scientific gloss (Pennock, 1999), its emergence provided part of the impetus for the educational controversy heating up again. In 2002, the American Association for the Advancement of Science (AAAS) passed a resolution opposing the teaching of intelligent design in public schools because it lacked sufficient supporting evidence to make it a scientific theory (Pinholster, 2002). However, three years later, President George W Bush reportedly supported the teaching of intelligent design as a theory in competition with evolution (Baker & Slevin, 2005; Padian 2009). Shortly afterwards, in the case of Kitzmiller v Dover Area School District, Judge Jones ruled that intelligent design was a religious view, a re-labelling of creationism rather than a scientific theory, so should not be taught (Guardian, 2005; Moore, 2007). A survey by the National Science Teachers Association in the same year found that 30% of Science teachers felt under pressure to reduce their emphasis on evolution or drop it altogether, with most of the impetus coming from students and parents (Workosky, 2005). Although the sample size was over 1000, the findings should be treated with caution, as respondents were those members of a professional association who chose to respond via a weekly email newsletter and are not necessarily representative of the wider teaching community.

Over 80 years after the Scopes trial, commemorated by so many as a great public relations triumph for pro-evolutionary thinking (Grabiner & Miller, 1974), teaching of evolution in the United States remains a contentious issue.

3.1.2 Turkey: An Islamic perspective

The threat to the teaching of evolution in Turkish secondary schools is a relatively recent phenomenon. Although the vast majority of its population is Muslim (Peker et al., 2009), Turkey is a secular state. One of the major aims of the Turkish Republic when it was founded in 1923 was a reduction in the influence of Islam. Reforms included the introduction of the teaching of evolution in schools (Sayin & Kence, 1999).

Sayin and Kence (1999) describe how tensions between secular and religious groups, which started in the 1950s, led to the secularists losing ground in the 1980s and 1990s as religious fundamentalist parties became involved in government. In the mid-1980s, under this more religious regime, an anti-evolutionary approach began to develop in secondary education with the appearance of state-sponsored creationist material (originating from the US Institute for Creation Research) and creationist textbooks (Edis, 1999). Political paranoia was heightened when a government circular to schools branded as communists those who taught and supported evolution (Sayin & Kence, 1999).

According to Sayin and Kence (1999), although textbooks still covered evolution, it was in a distorted and non-scientific way alongside creation as an alternative “hypothesis”. They report that this situation prevailed until a new government was elected in the late 1990s when textbooks were rewritten with a more objective angle on evolution.

Nevertheless, Peker et al. (2009) maintain that contemporary Turkish students are more likely to encounter religious than scientific explanations of the origin of life. This is because, whilst religious doctrines are taught to all students from Islamic families, students who choose not to study science beyond the age of compulsion drop it before evolution is covered in the 11th grade (around 17 years old). Even then creationism and evolution are treated as alternative theories. Furthermore, a study by Somel, Somel, Tan and Kence (2006, as cited in Peker et al., 2009) found that more than half their sample of biology and elementary Science teachers did not fully accept evolutionary theory. Higher rates of rejection were found amongst younger participants, who were themselves educated in an environment more positive to creationism than to evolution. There was a consequent reluctance to teach it in the classroom.

The science foundation of Turkey was one among 14 from Muslim majority countries who signed a recent statement by the Interacademy Panel (a global network of science academies) in support of the teaching of evolution, including human evolution (Section 3.3.3). Despite this, press reports in 2009 claimed that the national funding body for science had sacked the editor of its journal because she attempted to put Darwin on the front cover to celebrate his bicentenary (Kaufman, 2009; Nature, 2009). Various commentators have expressed concern that creationism may prevail over science in Turkey (see for example Edis, 1999 and Steve Jones, as cited in Graebsch & Schiermeier, 2006). Edis (2009) stresses that in Turkey, creationism has support across the spectrum, and Darwinism is widely seen as "a Western import, defended by westernizing elites within Muslim societies" (p. 889). The country has been described as "one of the main cradles of Islamic scientific creationism" (Lengagne, 2007, point 53). For instance, Harun Yahya, who has caused controversy by distributing the anti-evolutionary tome The Atlas of Creation across a wide range of recipients (including schools) and countries in recent years, hails from Turkey (Clément & Quessada, 2008; Lengagne, 2007).

The history of RE in Turkey is closely tied to changes in the political landscape. It was banned after the founding of the republic in 1923, and not re-instated until 1949 for primary schools, 1956 for lower secondary and 1967 for upper secondary. It existed on a voluntary basis until made compulsory after the 1980 military takeover. Recent reports from Reuters (Bektas, 2012; Cameron-Moore, 2012) announced that the ban on religious schools (madrasas) imposed by Ataturk soon after 1923 is likely to be reversed. This is proving controversial in Turkey's ongoing struggle between secular and religious political factions.

Kaymakcan (2002) reports that almost 100% of Turkey's population is Muslim and religiosity is high, as evidenced by attendance at prayers and fasting at Ramadan. He explains that because the public demands it, religious education is currently provided in the school subject entitled "Religious Culture and Ethics Knowledge". Rather than seeking to convert, it has the aim of informing students about Islam, other world religions and ethics. The curriculum includes a module on Islam and Science in Grade 10 (Gardom, 2010). One aim is for students to "understand the scientific researches, methods and results and be able to apply them to their life" (p. 29).

3.1.3 Across the globe: Interplay of evolution, politics and religion

Turkey is far from being the only country where the teaching of evolutionary theory is strongly influenced by the political system. The National Party in South Africa used a distortion of the Darwinian concept of "fitness" to justify the oppressive system of apartheid for over forty years (Lever, 2002). Yet ironically, evolutionary theory was absent from schools during this period. It was seen as contradicting the biblical version of creation at a time when one stated aim of the Biology curriculum was to encourage appreciation of the creator and the created universe (Abrie, 2010). After the regime was overthrown in 1994, evolution was re-introduced to the curriculum (Holtman, 2010) although only in the final year of the non-compulsory but popular Life Sciences (Allais, Dempster & Barlow-Zambodla, 2008).

According to Holtman (2010), evolution by natural selection remains the most controversial topic in South African schools. She reports an absence of training in the subject area for teachers who themselves might not have been taught about evolution and thus are particularly in need of support. There is also a lack of emphasis on evolutionary theory as an overarching, explanatory concept fundamental to biology.

Lower down the school, Abrie (2010) describes the curriculum using terms such as development and change over time rather than evolution, and wrongly defining natural selection as nature deliberately killing those less well adapted (rather than working through differential survival and reproductive success). In a very limited study at one, historically Afrikaans university, Abrie found that half the trainee biology teachers rejected evolutionary theory and two-thirds felt that teachers who disagreed with it should not be forced to teach it. Holtman (2010) identifies the curricular requirement to consider faith-based and indigenous knowledge as another potential barrier to teaching evolution.

In Saudi Arabia, where the king heads up the education committee, the published objectives of science education include highlighting the Islamic world's contribution to science and showing that science and Islam can exist in harmony (Burton, 2010). To reinforce this, Qur'anic verses are threaded through science textbooks. Evolution appears for the first and only time at twelfth grade, with two pages dedicated to discrediting the theory because it contradicts Qur'anic teachings. The theory is clearly identified as Western in origin, and claims are made that it lacks any basis in evidence and is widely disputed even by scientists in the West (Burton, 2010).

Burton (2010) contrasts the Saudi approach with that of Iran, where religious references in the textbooks are confined to non-explicit allusions to the creator of the world and natural laws. She describes how fifth grade students (final year of primary school) learn that science has traced the origin of life in the sea and the progress to land. The eighth grade (the last compulsory year of schooling) introduces natural selection. However, human evolution is not mentioned. According to Burton, evolutionary theory was introduced into Iranian textbooks from around 1925 when the westernising Pahlavi shahs came into power and remained there, although the name of Darwin himself was dropped for a short period (1984-1998) after the 1979 Islamic Revolution.

Pakistan is another country where science and religion are closely inter-related in education, with Qur'anic verse quoted in science textbooks (Asghar, Wiles & Alters, 2010). Despite this, evolution is treated as a scientific fact although the evolution of humans is not touched upon and Allah is presented as fundamental in creating and maintaining the universe (Hameed, 2008).

Israel, with its predominantly Jewish population, has a different religious make-up to other Middle Eastern countries. About one-fifth of Jewish Israelis attend religious state schools where an additional curricular goal is to teach that humanity has special status as it was created in God's image (Burton, 2011). Because the evolution unit is not compulsory in state schools, Burton suspects that many teachers do not cover it to avoid conflict with students. The avoidance of internal conflict may provide another motivation: a small study of Science teachers in the religious state system (Dodick, Dayan & Orion, 2010) suggests that around half of them could not reconcile the biblical creation story and Darwin's theory of evolution.

The US may be the most prominent and widely-cited majority Christian country to find evolution educationally controversial, but there are others. Within Europe, there are recent examples of evolutionary theory being withdrawn from the curricula of some predominantly Christian countries. For instance, Prinou, Halkia and Skordoulis (2005) report that it has been removed from Upper Secondary schools in Greece since 2000, and suggest this might have been prompted by opposition to the theory from the orthodox church. Moreover, for younger Greek students it is the last unit of the year and often does not get covered for lack of time (Lengagne, 2007; Prinou et al., 2005). According to Graebsch and Schiermeier (2006), in 2004 Italy temporarily withdrew evolution from middle school curricula citing fears that it might promote materialism.

Even in countries where evolutionary theory forms an accepted part of the curriculum, high-level dissent can be expressed. The Serbian Minister of Education had to resign in 2004 after she instructed schools that they could only continue teaching Darwinist evolution if they also covered creationism (Lengagne, 2007). Lengagne also relates that, in 2006, the Polish deputy minister of education called the theory a lie. Two years later in Northern Ireland, the chair of the education committee (Mervyn Storey) said that creationism and intelligent design should be covered alongside evolutionary theory and admitted that his personal preference was for evolution to be excised from the curriculum altogether(McCrory & Murphy, 2009):

> Creationism is not for the RE class because I believe that it can stand scientific scrutiny... This is not about removing anything from the classroom - although that would probably be the ideal for me ... (p. 374).

Although evolution education in Canada has been much less contentious than in the neighbouring USA, its Social Sciences and Humanities Research Council recently suggested that there was no evidence to favour the theory of evolution over intelligent design (Wiles, 2006). Roth (2010) reports that the Canadian minister for science failed to give a clear response when asked whether or not he believed (sic) in evolution. Wiles suggests that school students are not always receiving an adequate grounding in evolutionary theory. He points to the situation in Quebec, where – although it is on the curriculum – the theory seems to be taught erratically if at all. At higher stages of schooling evolution is optional and consigned to the very end of the course.

This relegation to the end of the curriculum is found in other countries, Kenya and Ghana being two examples (Allais et al., 2008). Because these countries do not treat evolutionary concepts as integral to the teaching of biology, evolutionary theory may be excluded altogether as a result of time pressures and its importance either understated or ignored.

Some curricula, such as Zambia (Allais et al., 2008) and Malaysia (Loo, 2001; Ministry of Education Malaysia, 2006) do not include the theory of evolution at all. Loo describes how the 1991 Malaysian secondary school curriculum restricted itself to the claim that humans were created to look after the earth and ignored modern evolutionary theory completely. Little seems to have changed in Malaysia's 2006 biology curriculum: the document asserts the importance of individuals having "a firm belief in and devotion to God" (p6), and there is no mention of evolution even though genetic mutation and the importance of variation in the survival of species are covered (Ministry of Education Malaysia, 2006). The suggested learning activities for the unit on variation include "conduct a sketch to show respect for all God's creation" (p45).

In a study of 19 countries, Clément (2008) found a wide variation in the coverage of evolution in biology syllabuses. He argues for giving it more prominence in those syllabuses where its profile is currently low or non-existent. About half the countries included some evolution at the primary (under 12 years of age) level. Lithuania incorporated evolution at the highest number of levels (8: 2 primary and 6 secondary), followed by France and Finland (both at 6 levels including one primary). According to his analysis, evolution featured in three secondary levels in Great Britain. In the Algerian, Lebanese, Moroccan and Burkina Faso syllabuses, evolution did not appear at all. Apart from Burkina Faso, these are all Muslim majority countries (Clément, 2008).

Some school systems have a confessional approach to RE. That is, it is taught from a particular faith or doctrinal viewpoint, often by members of the church or religious community concerned. Where the approach is non-confessional, RE aims to impart knowledge about religious beliefs and practices without trying to initiate a desire to participate. Some commentators hypothesise that the presence of non-confessional RE in the curriculum might reduce the perceived conflict between science and religion (Long, 2010; Roth, 2010). Table 3.1 (overleaf) summarises the nature of RE in a selection of European countries, showing no consistency of approach concerning whether the subject is confessional or non-confessional, compulsory or optional. From the data available, there is no obvious pattern between these features and the way evolutionary theory is covered, but more information is needed.

Table 3.1: Situation of RE in different European countries

Country	Compulsory?	Confessional?	Additional comments
*Austria	✓	✓	
*Estonia	x	x	only 29% of population self-define as believers: much suspicion about RE
Finland	✓	weak	mainly from Lutheran perspective
Germany	✓	✓	varies by federal state (Länder) but mostly as shown
Italy	✓	✓	mainly Catholic
*Latvia	x	x	
*Northern Ireland	✓	✓/x	confessional in Catholic schools, non-confessional and neutral in state-controlled (mainly Protestant) schools
Norway	✓	x	
Poland	x	✓	
*Romania	(x)	✓	compulsory in primary, opt out rare in secondary as 99% of population belong to a religion.
Slovakia	(x)	✓	choose ether RE or Ethics; RE is compulsory in church schools.
*Spain	x	✓	mainly Catholic; compulsory to offer it but optional to take it.
Sweden	✓	x	
Switzerland	✓	✓/x	confessional or not varies by administrative region (canton)

Sources: Ziebertz and Riegel (2009) except for those asterisked which are from The European Forum for Teachers of RE at http://www.eftre.net/

3.2 UK context

Creationism is a much less prominent issue in the UK than in the United States and consequently causes less controversy in an educational context (Coleman & Carlin, 2004; Numbers, 2006; Williams, 2008). Several explanations for this have been mooted, primarily relating to religious practices or legislation about teaching RE in the UK.

In terms of religious factors, Numbers (2006) points out that British evangelical Christians, unlike American ones, have always been in a minority. As a result, they have adopted a more tolerant stance and tended to be more doctrinally liberal, making biblical literalism much less common. Coleman and Carlin (2004) consider that the more centralised nature of religion and education in the UK has left both spheres less accessible to smaller interest groups, including creationists. They, too, draw attention to the different nature of Christian groups in the UK, citing lower levels of belief and practice and fewer conservative Protestants. It is notable that in Northern Ireland, where conservative Protestantism (as well as Catholicism) has a much higher profile, creationism is more of an issue than it is elsewhere in the UK (McCrory & Murphy, 2009).

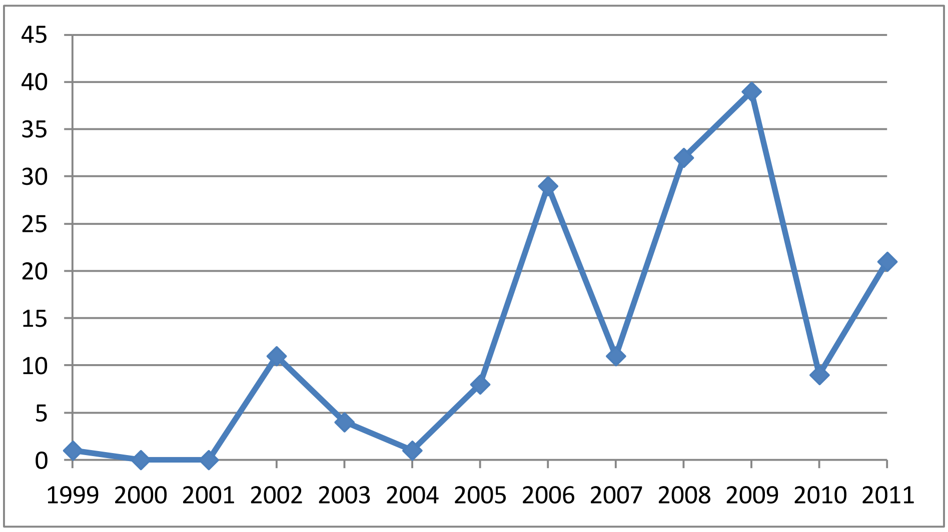
Williams (2008) suggests that the presence of RE in state schooling may have contributed to the relative lack of debate in the UK. However, Dingwall and Aldridge (2006) worry that "government encouragement of faith-based schooling" is reversing a decline in creationism in the UK. The only evidence they cite in support of this view is a 2002 incident of creationism allegedly being featured at privately-sponsored Emmanuel College (see below) and the possible involvement of the same organisation with further schools.

The contrast between the US and the UK is highlighted when science textbooks are examined. Compared with the historical patterns that can be traced through the study of textbooks in the US (outlined in Section 3.1.1) coverage of evolution in UK textbooks seems to have been reasonably uniform. Williams (2008) draws attention to a popular 1950s biology textbook. Its Catholic author declares in the preface "it is assumed that the reader believes in the existence of God, and accepts the logical consequences of the fact" but proceeds to give extensive coverage of evolution consistent with the model proposed by Darwin. Since then, according to Williams, textbooks have presented scientific facts with no reference to God.

There was recently some controversy in the press over the GCSE science specification from OCR requiring that students should be able to "explain that the fossil record has been interpreted differently over time (e.g. creationist interpretation)" (Halpin, 2006; MacLeod, 2006; Paton, 2006). The matter was raised in a government committee (House of Commons, 2006) and the text in parenthesis was absent from the next version of the specification (OCR, 2008). Scrutiny of current textbooks shows that relevant references to religion are generally restricted to consideration of the contemporaneous reaction to Darwin's publication and the reasons why his theory was not immediately accepted by the scientific community or wider society (for more detail, see Section 3.3.1).

A study of media coverage shows that the UK profile of the evolution/creationism debate rose early in the twenty-first century (Allgaier & Holliman, 2006; Williams, 2008). The pattern of saliency in the news media is illustrated in Figure 3.1. This shows the results of an analysis of world news archive material for The Guardian, chosen because it was the only UK-wide "serious" newspaper to offer free on-line access to its archives. Articles were retrieved using the search term "creationism" and annual figures have been plotted. Although relatively unsophisticated, the procedure demonstrates that creationism was virtually absent from news coverage prior to 2002. It grew in prominence over subsequent years, peaking in 2006, 2008 and 2009. It is also interesting to note that, although the search term was "creationism" in isolation, a high proportion of the articles were directly linked to educational issues.

Figure 3.1: Pattern of media coverage of creationism (based on *The Guardian*)



Base: number of news articles containing word "creationism" in *The Guardian* 1999-2011

The spikes in the graph coincide with particular incidents that are outlined in more detail below. Three events are of particular relevance to this research: concerns over teaching creationism at Emmanuel College in March 2002; distribution of intelligent design material to schools in 2006; and Michael Reiss's speech about how best to tackle creationism in the classroom and his subsequent departure from the Royal Society in September 2008.

Many commentators identify the 2002 episode at Emmanuel College, a school in the north-east of England, as precipitating the recent controversy over the teaching of evolution and creationism in the UK. It has been widely covered in both the popular press (Branigan, 2002; Bunyan & Bonthrone, 2002; Herbert, 2002) and the academic literature (Allgaier & Holliman, 2006; Numbers, 2006; Williams, 2008). The nature of the school – one of a new breed of city technology colleges (CTCs) - added to the sensitivity of the matter. Most children in England (90%) attend non-fee paying, state-maintained schools. CTCs were set up as part of this system, but they are independently managed through a public/private partnership and were given the freedom to vary the statutory national curriculum. The private sponsor involved at Emmanuel College is the Emmanuel Schools Foundation. This is headed by Peter Vardy, a local businessman who, according to Williams, claims to believe in a creator God although not in the literal truth of the biblical account. Although the school declares it is open to students from all faiths and none, part of the mission statement is "to encourage personal, moral and spiritual development within a Christian framework" (Emmanuel Schools Foundation, n.d.).

The controversy began unobtrusively with a brief article in the Times Educational Supplement (Dean, 2002) announcing that the school had agreed to host a two-day creationist meeting. Over a month later, this was followed up on the weekend of the conference by a more inflammatory report in the Guardian (Branigan, 2002). It claimed that "fundamentalist Christians who do not believe in evolution have taken control of a state-funded secondary school in England". This prompted a spate of media coverage accusing the college of teaching creationism in addition to evolution.

An analysis by Allgaier and Holliman (2006) makes the scale of the UK newspaper coverage apparent. Of the 287 articles they identified as addressing the issue of teaching creationism and evolution from 1 January 2002 until 20 February 2004, over a third (105) were published in March 2002. As time progressed, Allgaier and Holliman identified a shift in focus of the content of articles from narrow, school-specific considerations. The wider themes ranged from whether it was right to mix state and private funding of education (CTCs and academies) to fundamental questions about the science curriculum: should its purpose be to develop scientific citizens by covering contemporary issues relevant to everyday life or should it concentrate on facts and formulae?

The contretemps resulted in at least three petitions being sent to the government (Allgaier & Holliman, 2006). One, spearheaded by the British Humanist Association, demanded tighter legislation to stop creationism being taught in science. Another, led by the Bishop of Oxford, argued for clear separation of science and religious curricula in faith schools. A third, from various scientists and academics, supported the National Curriculum wording that encouraged critical appraisal of alternative theories. This last was led by Andy McIntosh, a young earth creationist linked with Answers in Genesis and, according to Williams (2008), a director of the intelligent design organisation, Truth in Science. Williams reports that concern was raised when the prime minister (Tony Blair) failed to explicitly condemn creationist teaching in science lessons. Allgaier and Holliman argue that the removal of Darwin's theory as an example of a scientific controversy from the subsequent revision of the KS4 programme of study was at least partially as a consequence of media coverage of this incident.

Mention of creationism in the press (as represented by the Guardian) fell back again before increasing dramatically in 2006. The Guardian interviewed the Archbishop of Canterbury, Rowan Williams, early in the year. His statement that he did not agree with the teaching of creationism as a theory in schools (Rusbridger, 2006) stimulated debate.

Around the same time, there was coverage of a campaign to limit the influence of religious organisations on state schooling, including banning the teaching of creationism (Smithers, 2006). In autumn, Truth in Science - a newly formed organisation promoting intelligent design - sent out resources to every secondary school in the UK. The material included a DVD questioning the evidence for Darwin's theory of evolution and encouraging schools to "teach the controversy" in science lessons (Williams, 2008). Considerable publicity followed and it was claimed that 59 schools were actually using the pack in the classroom (Randerson, 2006). On their website, the organisation describes the material as follows:

> The Truth in Science resource pack describes and critiques Darwin's theory of evolution on a scientific basis. It also shows scientific evidence suggesting that the living world is intelligently designed. (Truth in Science, n.d.)

After a fairly quiet 2007, the debate between evolution and creationism flared again in the latter half of 2008. After the Republican candidate for the US presidency, John McCain, announced Sarah Palin as his running mate, her support for the teaching of creationism in schools was widely featured (Goldenberg, 2008). But it was an incident in the UK that provided the stimulus for many of the column inches devoted to the subject: an address to the British Science Association's annual Festival of Science by Michael Reiss, Director of Education at the Royal Society. Consistent with his previously expressed views (see for instance Reiss, 2008b), he suggested that creationism should be treated as a worldview rather than a misconception, and that if a Science teacher felt comfortable engaging with religious beliefs when raised by a student, it would be best educational practice to do so. The speech was reported in the Guardian under the headline "Teachers should tackle creationism, says science education expert" (Randerson, 2008). Much was made of Reiss being an ordained Anglican priest as well as an evolutionary biologist, and three high profile Royal Society fellows sent a letter to the president demanding that Reiss step down (McKie, 2008). Intense media coverage followed, and the affair culminated with Reiss and the Royal Society parting company – a move Reiss later acknowledged was forced upon him (Crawley, 2009).

The highest number of articles mentioning creationism was recorded in 2009, primarily due to events connected with Darwin's bicentenary. For instance, several organisations took the opportunity to publish polls and surveys about evolution and creationism; a biopic about Darwin was released in cinemas; and Andrew Brown (editor of the belief strand of the Guardian's "Comment is Free") devoted a number of blogs to the topic. Also in 2009, a court case in the US ruled that a history teacher had violated the first amendment not to denigrate religion when he dismissed creationism as “superstitious nonsense” (Butt, 2009a).

Following the flurry of coverage in 2009, 2010 was a reasonably quiet year, but interest in the topic seemed to revive in 2011. There was no single focus to the coverage, but Andrew Brown again featured creationism quite often in his blog columns.

3.3 England: coverage of origins in Science and RE

This section clarifies the place of Science and RE in the curriculum of state-maintained schools in England before examining the coverage of origins in KS4 subject specifications and textbooks. Opportunities for considering the interface between the two disciplines are highlighted. Both the origins of life and of the universe are considered because, as will be seen later in the thesis (eg Section 7.3) the two were often confused by research participants.

3.3.1 Science curriculum

Science forms a compulsory component of the National Curriculum for England and there is a statutory programme of study from Key Stage 1 to Key Stage 4 (leading to a national examination, typically GCSE). There are some key ongoing discussions about the nature of the science curriculum, for instance: should it aim to produce scientifically literate citizens or is its primary purpose to train future scientists?; how can it be re-designed to retain more students post-16?

One influential report to emerge from this debate is Beyond 2000 (Millar & Osborne, 1998), which makes recommendations about the future of science education. The authors list a limited number of key ‘explanatory stories’ that should feature in a pared-down curriculum. Chief among these is how the universe was created through the big bang. Evolution by natural selection is also emphasised, being described as introducing “important and challenging ideas about the huge timescales over which change occurs. Moreover, it offers us a radically different view of who we are – the product of random variation and selective survival” (p. 4). Millar and Osborne also consider it important that students appreciate how new scientific ideas can meet opposition for various reasons, including religious challenges. Although the illustration they give of the latter is Copernicus, Galileo and the solar system, it could equally well be Darwin and the theory of natural selection.

The science programme of study for Key Stage 4 outlines what schools must teach (QCA/DfES, 2004a). During the period of this research (2007 – 2009), the expectation was that the knowledge, skills and understanding of how science works would be applied across four key areas: organisms and health; chemical and material behaviour; energy, electricity and radiations; and environment, earth and universe. Students are expected to cover how variation within species can lead to evolutionary change, and – although there is no explicit mention of the big bang – to study how the solar system has changed since its origin. Within 'How science works', the section on data, evidence, theories and explanations is particularly relevant to the study of the origin of life and discussion of Darwin's theory:

> Pupils should be taught:
>
> a) how scientific data can be collected and analysed
>
> *b) how interpretation of data, using creative thought, provides evidence to test ideas and develop theories*
>
> c) how explanations of many phenomena can be developed using scientific theories, models and ideas
>
> *d) that there are some questions that science cannot currently answer, and some that science cannot address.* (p. 5, emphases added)

This study took place at a time when the majority of GCSE students were entered for two science GCSEs. One GCSE comprised a common core of science, the other a component with either an applied or more academic slant. The remainder of this section concentrates on the core science GCSE and examines the specifications of the three main awarding bodies in England (AQA, Edexcel and OCR). Each body publishes its own science specification(s), based on the criteria developed by the QCA (now defunct). Where foundation or higher tier are mentioned, this relates to levels of assessment with foundation being lower demand.

The specifications have been studied to identify parts in which the inter-relationship between science and religion might be relevant. The reasoning behind selecting the four areas listed in Table 3.2 is as follows:

- "scientists cannot be certain how life on Earth began" addresses issues about the boundaries of the discipline;
- the initial acceptability of the theory was affected by the religious climate of the time;
- "conflicting theories" could include scripturally-based explanations;
- consideration of the supporting evidence might involve drawing distinctions between scientific and other forms of evidence.

Table 3.2 shows whether or not each area is present in each specification. There are some commonalities. For example, there is universal inclusion of the evidence for evolution and of why Darwin's theory was not accepted immediately (except for foundation tier in OCR Gateway science). All except Edexcel mention contrasting Darwin's evolutionary theory with other, conflicting ones (again, excluding the foundation tier in OCR Gateway). However, AQA is the only body to specify that students should learn that scientists cannot be sure how life on earth began.

Table 3.2: Coverage of evolutionary theory in GCSE specifications

	AQA	OCR Gateway	OCR 21st Century	Edexcel
scientists cannot be certain how life on Earth began	√	x	x	x
why Darwin's theory not accepted immediately	√	√ (higher tier only)	√	√
contrast Darwin's theory of evolution with conflicting theories	√	√ (higher tier only)	√	x
consider evidence for evolution eg fossils	√	√	√	√

Based on awarding body specifications
√ = present; x = not found

Six textbooks which follow the 2006 specifications have been examined to establish how they cover the topic of evolution. There were two publications available to inspect for AQA and OCR Twenty First Century Science, and one each for OCR Gateway and Edexcel (Table 3.3).

Table 3.3: Textbooks examined for each GCSE specification

Specification	**Textbooks**
AQA	Clyde, Cox, Hirst, Hiscock, & Stirrup, 2006
	Heslop, Hill, Houghton, & Witney, 2006
OCR Twenty First Century Science	Burden, Grayson, Hall, & Large, 2006
	Ellis et al., 2006
OCR Gateway	Dawson, McDuell, & Brimicombe, 2006
Edexcel	Conoley, Jones, & Sang, 2006

Where there was a choice, the higher tier rather than foundation textbooks were consulted.

All the textbooks allude to the controversy surrounding Darwin's theory when it was first published, and why it was only gradually accepted. In this way, they illustrate the nature of a theory, the role of evidence, and the importance of the social context that a scientist works in.

The AQA specification is the most comprehensive in its coverage, and this is reflected in one of the course textbooks (Heslop, Hill, Houghton, & Witney, 2006). It includes an activity which asks students to consider five different theories for the evolution of plants and animals, to think about how they conflict and to decide which is the most convincing. The theories listed are creationism, Buffon, Lamarck, Cuvier and Darwin (see Section 2.1 for more detail). Purists might criticise the text of this exercise for a rather slack use of language, in particular including creationism under the umbrella term "evolution" and using the word "theory" to describe it. Although the way this question is worded ostensibly encourages students to make their own decision, the text goes on to state that Darwin's theory of evolution is now widely accepted. In a further example of prejudging earlier student responses, it subsequently asks "why do you think Darwin's ideas give a better explanation of evolution?" (p. 69). In another task, pairs of students discuss how it is possible for many Christians to accept both God's role in creating life and Darwin's theory.

None of the other textbooks explores the issue in such depth. All state that the original reception from religious people was hostile, mainly because it undermined the idea that God made all living things (Burden, Grayson, Hall, & Large, 2006; Clyde, Cox, Hirst, Hiscock, & Stirrup, 2006; Conoley, Jones, & Sang, 2006; Ellis et al., 2006) or suggested humans were related to apes (Dawson, McDuell, & Brimicombe, 2006). However, only Burden et al. allude to the present-day situation regarding religious opposition, and that obliquely as "strong personal beliefs" that make the debate around evolution "unlikely to stop anytime soon" (p. 77).

The other AQA textbook (Clyde et al., 2006) devotes one double-page spread, headed "Challenging ideas", to Darwin's theory. After acknowledging the initial obstacles the theory faced, the text refers to disagreement over the mechanics, rather than the overall credibility, of evolution : "Although most people now accept that humans have evolved, scientists do not agree about how humans evolved" (p. 64).

One of the Twenty First Century science textbooks devotes six pages to the "Story of Charles Darwin" (Burden et al., 2006). It emphasises how he built the theory using observations and creative thinking. Describing the context in which Darwin was operating, the text declares that "almost everyone" in Victorian Britain was against the theory of evolution by natural selection because it contradicted the Bible (p. 76). Interestingly, the 2011 re-write (Edge et al.) changes this to read that "many people" objected because they were "unhappy about the idea that humans were related to apes". The reference to the Bible has been excised. Both editions, however, quote Pope John Paul II stating that "... new scientific knowledge leads us to recognise more in the theory of evolution than hypothesis" (p. 77, Burden et al., 2006; p. 95, Edge et al., 2011).

The other Twenty First Century science textbook (Ellis et al., 2006) asks students to give two reasons why Darwin's hypothesis was not immediately accepted; the preceding text implies they expect answers concerning lack of evidence as well as resistance from religious people. The Gateway science textbook (Dawson et al., 2006) takes a similar line, stressing the importance of evidence and "an open mind" in the scientific process (p. 60). Both textbooks use the opportunity to discuss the nature of a theory: how it develops from a hypothesis, and that it can never be proved.

Conoley et al. (2006) take a slightly more personalised approach in the Edexcel textbook, describing Darwin's worries about contradicting religious orthodoxy of the time, but adding that evidence has been collected to support the theory and that "gradually, his ideas came to be accepted" (p. 15).

The origin of the universe also features in the GCSE specifications, with all of them covering evidence for the big bang theory (see Table 3.4 overleaf). Edexcel lists two other main theories (steady state and oscillating), but OCR Gateway only recognises the existence of alternative theories in its introduction to the topic and the other two awarding bodies do not mention them at all.

However, not all the textbooks are completely in line with the specifications. Although Conoley et al. (2006) remain faithful to the Edexcel specification by describing all three theories and explaining that not everyone agrees about the big bang, Dawson et al. (2006), unlike the Gateway specification on which it is based, only mention the big bang theory. Campbell, Sang and Millar (2006) are consistent with the Twenty First Century science specification in only mentioning big bang theory. They recognise no uncertainty, declaring in an end-of-chapter list of what students should have learnt: "that the Universe began with a 'big bang' about 14,000 million years ago" (p. 34). Steady state is mentioned in all three remaining textbooks, albeit the Twenty First Century science textbook declares that the theory is no longer accepted by most scientists and suggests it as a subject for student's own research (Ellis et al., 2006).

Two textbooks use questions about the universe to draw boundaries around what science as a discipline can consider. Clyde et al. (2006) employ the header "Who created the Universe in the first place?" before carrying on to say "this is one of those questions that science will probably never be able to answer" (p. 228). Heslop et al. (2006) acknowledge that "Science cannot explain why the 'big bang' happened or when the Universe will end" (p. 231). They also use the big bang theory to clarify the nature of a theory which they define as "a good idea that helps explain some important observations. It may or may not be correct" (p. 231).

Table 3.4: Coverage of big bang theory in GCSE specifications

	AQA	OCR Gateway	OCR 21st century	Edexcel
consider evidence that universe started with a 'big bang'	√	√	√	√
examine alternatives to the big bang theory (steady state, oscillating)	x	(contextual only)	x	√

Based on awarding body specifications
√ = present; x = not found

It is difficult to surmise how the specifications are operationalised in the classroom. None of them explicitly mentions religion or religious beliefs so – although there is potential for discussing the interface – it is impossible to know how many teachers or students take up this opportunity.

3.3.2 RE curriculum

The position of RE is unique among school subjects in England. Although it is statutory, it does not form part of the National Curriculum, and its syllabus is agreed locally. There is a legal requirement under the 1996 Education Act that RE should be taught to all students, apart from those in nursery classes and those withdrawn at the request of their parents. Section 352 of the Act states that the subject has equal status to those in the National Curriculum, and differs only in not having nationally set attainment targets or programmes of study.

Under the 1988 Education Reform Act, every local education authority must establish a Standing Advisory Council for Religious Education (SACRE). Duties of the SACRE include monitoring and periodically reviewing the appropriateness and effectiveness of the locally agreed syllabus. The SACRE is made up of representatives from the Local Education Authority, teaching staff and religious groups. The non-denominational RE syllabus it produces is statutory in community and voluntary controlled schools. In voluntary aided schools with a religious character, the governors determine how RE will be taught, in accordance with their trust deed. In academies (including free schools), those with no religious designation must adopt the locally-agreed syllabus from SACRE, whereas those with religious designation must provide RE in line with the specified religion, and may also teach about other faiths if they choose.

A national framework for religious education was published in 2004 by the QCA and DfES (2004b). Although this has no statutory standing, it has been devised with the declared intention of improving the quality of teaching and learning of RE in England's maintained schools. Aspects of it touch on the interface between religion and science and, more or less directly, with questions about the origins of life and the universe.

According to the document, religious education:

> ... provokes challenging questions about the ultimate meaning and purpose of life, beliefs about God, the self and the nature of reality, issues of right and wrong and what it means to be human. [...] challenges pupils to reflect on, consider, analyse, interpret and evaluate issues of truth, belief, faith and ethics and to communicate their responses. (p. 7)

Particularly relevant to the area under discussion, it should provide opportunities to discuss and reflect on "key questions of meaning and truth such as the origins of the universe" and "how beliefs and concepts in religion may be ... related to the human and natural sciences, thereby contributing to personal and communal identity" (p. 14). Cross-curricular opportunities include promoting "effective contributions to scientific, medical and health issues through exploring philosophical and ethical questions of the origin, purpose and destiny of the cosmos and life within it" (p. 16). The framework recommends tackling issues around the origin of life in Key Stage 2, when students should reflect on "their own and others' insights into life and its origin, purpose and meaning" (p. 27).

In Key Stage 3, one of the areas of study is religion and science specifically, with an emphasis on "issues of truth, explanation, meaning and purpose" as well as exploring connections between the two subject areas (p. 29). It should be noted that, although there is a specific cross-reference to the Science curriculum, this is not mirrored in the equivalent document for Science (QCA/DfES, 2004a).

A new RE unit entitled 'How can we answer questions about creation and origins?' and aimed at Year 9 (age 13-14) was published by QCA in 2006. The unit focuses on creation and the origins of the universe and human life, as well as the relationships between religion and science. Opportunities for students to learn through argument, discussion, debate and reflection are stressed. The unit introduces the origin of the universe and of human beings as providing students with the opportunity to develop an attitude of "appreciation and wonder" and to recognise that "knowledge is bounded by mystery" (p. 2). Specific questions addressed include:

> Does a complexly functioning world imply a creator God? (p. 11)
>
> How do people account for their views about the origins of the universe? (p. 13)
>
> What do people believe about the origins of the universe and human existence? (including the concepts of evolution, creationism and intelligent design) (p. 16)
>
> What is the relationship between religion and science for believers? (p. 18)
>
> Will humans ever really know for sure how the universe came about? (p. 20)

Threaded throughout the module are opportunities to consider the origins of the universe and of human life together. These are explicitly conflated under the second question in the above list, where students are encouraged to consider "what they already know about evolution and big bang theory" as if both are scientific explanations for the origin of the universe. It is also important to note that, for students who follow the unit, this will probably be the first time they engage with evolution or the big bang, as these theories are not covered in the science curriculum until Key Stage 4 (Section 3.3.1). The other main curricular opportunity to cover evolutionary theory at this age occurs in history (a non-statutory Year 9 unit encompassing important scientific discoveries, which incorporates a section entitled "Charles Darwin: are people just another species?") (QCA, 2000).

The Programme of Study for those aged 14-19 (QCA, 2007) states that learning about religion should enable students to:

> reflect critically on their opinions ... develop their independent values and attitudes on moral and spiritual issues ... evaluate issues, beliefs, commitments and the influence of religion ... [and] use skills of critical enquiry, creative problem-solving and communication through a variety of media. (p. 279)

Opportunities to "explore the connections between RE and other subject areas" (p. 281) should also be provided.

Some students choose to follow a route that gives them an RE-based qualification, studying GCSE "Religious Studies" as either a short or full course. Depending on the awarding body, the GCSE specifications include some consideration of the contrasting natures of science and religion:

- how science and religion are connected (principles, purposes, methods, belief and experience) and the ways in which some scientists see science as leading to or supporting belief in God (Edexcel, 2003);
- scientific truth based on observation, hypothesis, experiment, repeated testing; and spiritual truth based on religious authorities, sacred writings and conscience (AQA, 2006).

Several of the GCSE options address the religious and scientific approaches to the origins of the universe and of life. Evolutionary theory is often presented alongside the big bang in the GCSE units:

- origins of life - scientific and religious views of how life began and developed / evolved (Specification B, AQA, 2006);
- how the appearance of the world (design and causation) may lead to or support belief in God/Allah and how non-religious explanations of the world and of miracles may lead to or support agnosticism or atheism (Edexcel, 2003);
- religious cosmology and the attitudes of its followers to it, alongside scientific cosmology (big bang and evolution) and religious attitudes to it (Edexcel, 2003);
- the extent to which religious views about the origins of the world and of humanity can be compatible with scientific theories, including “very basic understandings” of the big bang theory and of Darwinian evolutionary theory (Specification B, OCR, 2000).

If QCA guidance is followed, or if students take GCSE Religious Studies, they should have opportunities to consider religious and scientific explanations of origins alongside each other. However, two major concerns are raised. Firstly, the muddle about the division between origins of the universe and of life in the written documentation may be perpetuated in the classroom. Secondly, if the theories of evolution and the big bang are dealt with in RE before students have encountered them in Science, there is a risk that the scientific complexities might not be adequately (or accurately) covered.

3.3.3 Official guidance on dealing with creationism

The discussion about religious beliefs and whether they have any place in the science classroom has been dominated by reference to creationism and, more recently, intelligent design. During 2006 and 2007 there were several recommendations from public bodies about the teaching of creationism in science lessons. The four which will be considered here were issued by the following bodies:

- Interacademy Panel (IAP): an international organisation formed to help member academies provide advice to citizens and public officials on the scientific aspects of critical global issues.

- Council of Europe: an organisation of European member states (not to be confused with the EU) whose priorities are to uphold human rights, democracy and the rule of law.
- Department of Children, Schools and Families (DCSF): UK government department concerned with the welfare and education of children and young people (now the Department for Education).
- The Association for Science Education (ASE): the professional association for UK Science teachers.

All four organisations emphasise that creationism and intelligent design are not scientific theories, and must not therefore be given equal treatment alongside evolution in the science curriculum. Instead, religious or cultural studies is commonly suggested as a more appropriate forum. Where some disagreement arises is over the degree to which discussion of religious beliefs should be tolerated in the science classroom if raised by a student.

The IAP statement on the teaching of evolution was the first to be released, appearing in June 2006. That it was only the eleventh statement the panel had issued since its founding in 1993 demonstrates the seriousness with which it views the issue. Around two-thirds of the member academies have signed the statement, including the Turkish Academy of Sciences and the US National Academy of Sciences, as well as The Royal Society in the UK. The introductory paragraph explains the motivation behind it:

> We, the undersigned Academies of Sciences, have learned that in various parts of the world, within science courses taught in certain public systems of education, scientific evidence, data, and testable theories about the origins and evolution of life on Earth are being concealed, denied, or confused with theories not testable by science. (IAP, 2006)

The document sets out the IAP's position, enumerating a series of facts about the age of the Earth and the evolution of organisms from a common ancestor that it presents as evidence-based and indisputable. It stresses that science is confined to the natural world and generates testable, refutable hypotheses: "Human understanding of value and purpose are outside of natural science's scope". Nevertheless, it recognises the inter-connection of science and religion, and that mutual respect should be maintained alongside an appreciation of the limits of each domain.

In the year following the IAP statement, the Council of Europe issued a resolution which was adopted by its assembly in October 2007. Bluntly entitled "The dangers of creationism in education", it urges education authorities in member states to:

> firmly oppose the teaching of creationism as a scientific discipline on an equal footing with the theory of evolution and in general the presentation of creationist ideas in any discipline other than religion [and] promote the teaching of evolution as a fundamental scientific theory in the school curriculums (Council of Europe, 2007)

Intelligent design is identified as a refined, subtle and therefore more dangerous version of creationism, adopting a scientific veneer to inveigle its way into the science classroom. The Council's view is that the debate would be more appropriate in RE: "creationist ideas, as any other theological position, could possibly be presented as an addition to cultural and religious education, but they cannot claim scientific respectability". Science, it argues, is confined to the how rather than the why.

In England, the government issued its "Guidance on the place of creationism and intelligent design in science lessons" the month before the Council of Europe's resolution was agreed, and it takes a slightly softer tone. Although making it clear that creationism and intelligent design are not scientific theories and should not be treated as such, the guidance goes on to explain how the issue can represent a positive opportunity in the science classroom:

> Creationism and intelligent design are not part of the science National Curriculum programmes of study and should not be taught as science. However, there is a real difference between teaching 'x' and teaching *about* 'x'. Any questions about creationism and intelligent design which arise in science lessons, for example as a result of media coverage, could provide the opportunity to explain or explore why they are not considered to be scientific theories and, in the right context, why evolution is considered to be a scientific theory. (DCSF, 2007, italics in original)

Furthermore, it suggests that Science teachers might support those RE, history or citizenship teachers who choose to deal with creationism and intelligent design.

The ASE advice on "Science education, intelligent design and creationism" was issued in the same month as the DCSF document (ASE, 2007). As an association representing several thousand individuals with an interest in science education, it begins by acknowledging that some of its members will disagree with its stance. The ASE makes an unequivocal proclamation that intelligent design lacks any scientific underpinnings and therefore has no place in school science education - not even as an illustration of controversy in science. It recognises that lessons dealing with belief systems might choose to consider intelligent design, but urges them not to present it as scientific theory.

The arguments for and against including religious explanations in science lessons will be rehearsed in a later chapter (Section 5.2.3). Outside the creationist and intelligent design movements, there are no explicit calls to include these approaches within the science curriculum. However, several commentators are concerned about whether teachers are adequately prepared to handle the issues if and when they arise. Cobern (2004) considers many teachers lacked the skills to facilitate these potentially sensitive discussions in increasingly multicultural classrooms. Hermann (2008) identifies a need for professional development to enable teachers to tackle evolution as a controversial issue. He recommends they are trained to employ procedural neutrality (where the teacher adopts a neutral position and different points of view are elicited from students and resource materials). This pedagogical approach is discussed in more detail in Section 5.1.5.

The need for appropriate training has been highlighted by other studies. Research by Cleaves & Toplis (2007) based on interviews with 35 trainee and 29 experienced Science teachers raised questions about whether all teachers have a sufficiently scientific view of evolution, or enough training, to deal with “alternative theories” that may be aired in science lessons. Similarly, following a study of pre-service Canadian elementary school teachers, Asghar et al. (2007) called for better training of future teachers in these issues along with improved teaching of evolutionary theory.

The perceived need for professional development is not confined to teaching from a science perspective. Interpreting the DCSF guidance as assigning the main responsibility for covering creationism and intelligent design to RE teachers, the Science and Religion in Schools website has published advice aimed at those agreeing local RE syllabuses (SRSP, n.d.). It recommends examining creationism and intelligent design for theological credibility rather than casting them as scientific theories. The emphasis should be on the different concepts of truth and meaning in science and religion. It concludes that RE teachers need to have “a sufficient understanding of science and the limits of scientific discourse” and should avoid presenting science and religion as inevitably in conflict.

3.4 Summary

Even across the necessarily limited number of countries examined here, the educational policy on teaching evolution varies hugely and is strongly influenced by the religious and socio-political context in each nation. It is well-known that the US has a long history of controversy regarding coverage of the origin of life in the classroom, but it is not alone. There are examples of countries where evolutionary theory is ignored in the science curriculum (eg Zambia and Malaysia), discredited (eg Saudi Arabia), made optional (eg Israel) or relegated to the end of the course where it might never get taught (eg Greece, Canada).

In the past, the teaching of evolution has not been a particularly controversial issue in science education in England. However, if media coverage can be used as a barometer, sensitivity to tensions between evolution and creationism have increased over the past decade or so. Since 2006, when Truth in Science distributed materials promoting intelligent design to all secondary schools in England, two national bodies have issued advice about the coverage of creationism in the science classroom, and there have been additional European and international proclamations.

In this chapter, the content of curricula, specifications and textbooks as regards teaching the origin of life and the origin of the universe has been outlined. However, it is unclear how this is operationalised in school. This leads to the formulation of one of the research questions:

> *What are the differences, if any, between how the origin of life is dealt with in Science and RE classrooms?*

4. Opinion about how life originated

The purpose of this chapter is to look at opinions about alternative explanations for the origin of life among different groups of people. Attitudes of secondary school students will be shaped at least in part by the positions of the individuals around them. Since the main theme of this thesis concerns itself with potential differences between scientific and religious explanations of the origin of life, and how teachers present the topic in school, it is useful to explore the viewpoints expressed by representatives of these communities as well as members of the wider public in the UK and internationally.

4.1 Public opinion about evolution

4.1.1 UK, British and US data

There have been several surveys of the general public's opinion about the origin of life. Although data from the US predominates, latterly there have been a number of UK surveys and a few with an international perspective.

Despite some variation in response, recent surveys of the UK or British populations (BBC/MORI, 2006; British Council, 2009; Butt, Clery, Abeywardane, & Phillips, 2010; Lawes, 2009) all show that the proportion accepting naturalistic evolution outweighs those believing in the sudden creation of species by a supernatural being. In most cases, just over twice as many accept evolution without the involvement of a supernatural power as believe in a supernatural force creating species. Between 37% and 53% accept evolution with no supernatural intervention whereas just 16% to 22% believe human beings (or all living things) were created by God in their current form (Table 4.1 overleaf).

There is far more variability in the percentage opting for the combination of evolution guided in some way by a supernatural being: it ranges from 17% to 39%. The main factor in this seems to be how the response category was worded. The Theos survey (Lawes, 2009) split the option into two: that humans evolved by a process of evolution that can be seen as part of God's plan (28%) or that it required the special intervention of God or a higher power at key stages (11%). This resulted in a high total endorsement (39%). The British Council (2009) and the Wellcome Trust (Butt et al., 2010) surveys had similar wording to the first option and similar level of endorsement (25% and 27% respectively). The BBC/MORI survey was more similar to the second wording and, moreover, described itself as "intelligent design theory". It was chosen by only 17%. These issues around wording are picked up again in more detail later in the section.

Table 4.1: Public opinion about origin of life (UK/GB)

Survey	Country	Sample size	Evolution without God (%)	Evolution + God (%)	God without evolution (%)
[1]BBC/MORI (2006)	GB	2112	48	17	22
[3]British Council (2009)	GB	973	38	25	16
[2]Lawes (2009) for Theos	UK	2060	37	39	17
[3]Butt, Clery, Abeywardane, & Phillips (2010) for Wellcome Trust	UK	1179	53	27	18

Wording related to origin of:
[1]human life
[2]all living things
[3]life including humans

In the US, the ratio of endorsement for secular evolution compared with creationism is almost the reverse of the picture in the UK (see Table 4.2). The proportion of American adults adopting a creationist stance is between 43% and 51% with just 13% to 18% opting for evolution with no supernatural involvement (Alfano, 2005; NCSE, 2007; Gallup, n.d.; Virginia Commonwealth University, 2010). Between 24% and 38% favoured the explanation of a process of evolution with some supernatural input.

Table 4.2: Public opinion about origin of life (US)

Survey	Sample size	Evolution without God (%)	Evolution + God (%)	God without evolution (%)
[1]Alfano (2005) for CBS	808	15	30	51
[1]Newsweek (NCSE, 2007)	1004	13	30	48
[1]Gallup (n.d.) (survey: 2010)	1019	16	38	40
[2]Virginia Commonwealth University (2010)	1001	18	24	43

Wording related to origin of:
[1]human life
[2]all living things

Public surveys consistently show a relatively low acceptance of evolution across the US. Miller, Scott and Okamoto (2006) ascribe this to three factors: a high degree of biblical literalism in Protestant communities, the incorporation of the issue within party politics (such that it is identified with right wing Republicanism), and poor public understanding of genetics.

The research organisation Gallup has built up a time series of data on this subject that spans almost 30 years. It first asked for Americans' views on the origin and development of human life in 1982, and the figures show considerable stability over time up to 2010 (Gallup, n.d.). There has been a slight downward trend in the percentage believing in God directly creating species as they are today (44% to 40%), although it clings to its position as the most popular answer just ahead of evolution with God's guidance. Although remaining the least common answer by some margin, the proportion opting for human beings developing with no help from a God-type figure (secular evolution) has grown from 9% to 16%.

The Gallup figures also reveal that those with less education are more likely to believe in creationism (47% of respondents who did not get beyond high school compared with 22% of postgraduates) as are those with higher religiosity (60% of those going to church weekly versus 24% of those seldom or never attending). Politics tends to be quite bound up with religion in the US, with Republicans attending church far more frequently. Reflecting this, 52% of Republicans said they accepted creationism, compared with 34% of Democrats. This indicates that US rejection of evolution is more likely to be based on religious fundamentalism and political persuasion giving the issue, unusually, a political dimension in the US.

There are a number of possible reasons for the variability of the results from different surveys in the same country. Most fundamentally, the attempt to measure a complex and nuanced viewpoint in a single question represents a vast over-simplification. Often the studies demand that respondents choose between a very limited number of alternative explanations (usually three, occasionally four).

The evidence suggests that presenting people with such limited choice of response may force them into positions that do not accurately reflect their views. The British Council survey (2009) was unusual in explicitly providing an "other" option and it attracted 11% of the sample, who would otherwise have had to default to alternative responses (or non-response). Furthermore, in those cases where a survey has included more detailed supplementary questions, inconsistencies have surfaced. For instance, when a Harris poll in the US in 2005 (Harris, 2005) asked respondents which of three statements they believed about human origins, most (64%) believed humans were created directly by God and only 22% accepted evolution from earlier species. Yet elsewhere in the survey, much higher proportions of the same sample endorsed statements supportive of evolutionary theory: 38% agreed that humans developed from earlier species; 46% that apes and man have a common ancestry; and 46% that Darwin's theory of evolution is proven by fossil discoveries. Although 38% agreed humans *developed* from earlier species, only 22% of the same respondents agreed humans *evolved* from an earlier species, demonstrating the power of the word "evolution" and its derivatives.

A similar sensitivity is demonstrated by the experience of Gallup in the US, as chronicled by Bishop (2006). Perhaps concerned that its existing answer options were insufficiently precise, it changed the phrasing in 2005. The wording "human beings have evolved ... from other forms of life" replaced "human beings have developed ... from less advanced forms of life" in two options. In a third, 'God created human beings in their present form exactly the way the Bible describes it" replaced "God created human beings pretty much in their present form at one time within the last 10,000 years or so". Endorsement of the third statement increased from 45% to 53% compared with the previous year. The percentage opting for God guiding a process of evolution declined correspondingly, whereas the proportion choosing evolution without God's involvement stayed about the same. It is not clear which of the several changes caused this – the use of the term "evolved", citation of the Bible, dropping the 10,000 year time frame or a combination of factors. When Gallup reverted to the original phraseology the following year, the figures settled back to roughly the 2004 level, strongly suggesting that the aberrant data resulted from the modified wording.

Other comparisons provide further evidence of the importance of question wording, such that even subtle differences can trigger shifts in response patterns.

As shown in the footnotes to Tables 4.1 and 4.2, the wording of the questions specified either human life; all living things including (explicitly) humans; or all living things with no specific mention of humans. In the UK, this had no discernible effect on the results. In the US, there is a suggestion that – when humans were not specified – the proportion opting for evolution with no supernatural involvement increased.

In the UK, the survey reporting the lowest percentage of respondents (37%) choosing the position of evolution with no divine involvement (Lawes, 2009) used the following statement: "Humans evolved by a process of evolution which removes any need for God". This confounds two concepts and respondents might have inferred that accepting evolution meant rejecting belief in God.

The BBC/MORI (2006) survey prefaced each statement with a label: the "creationism theory"; "intelligent design theory"; and "evolution theory". It is impossible to measure the effect of these identifiers, but it may have contributed to the comparatively low percentage (17%) opting for the proposition: “the ‘intelligent design theory’ says that certain features of living things are best explained by the intervention of a supernatural being, e.g. God” (BBC/MORI, 2006).

Other surveys did not label the answer options in the questionnaire itself, but used such descriptions to report the results (ie, influencing interpretation rather than responses). This can be misleading particularly with the position that life has evolved through a guided process. There are examples where it has been termed “intelligent design” even though the description could equally apply to theistic evolution. For instance, in one survey the statement “biological life developed over time from simple substances, but God guided this process” was initially reported as the intelligent design position (Virginia Commonwealth University, 2005, p. 3), but in the 2010 repeat this was broadened to “an ‘intelligent design’ or a ‘theistic evolution’ view” (Virginia Commonwealth University, 2010, p. 2).

Another reason for contradictory data may lie in a lack of understanding or knowledge of the topic. Asked “how much have you heard or read about the theory of evolution?”, 44% of respondents in the Virginia Commonwealth University (2010) survey (US) said “a lot” and 23% said not much or nothing. In the British Council (2009) survey (GB), even fewer - 23% - claimed to have a “very good” understanding of evolution and 16% had no understanding or had never heard the term. It is difficult to gauge the accuracy of these self-reports, but it is clear that a considerable proportion of the sample is making a judgement about human origins with minimal or no knowledge of evolutionary theory.

4.1.2 International data

The British Council (2009) survey took place in nine countries in addition to Great Britain. Although there is no obvious logic behind the selection of the countries, it reveals an interesting pattern of views about how life on earth came into being (Table 4.3 overleaf).

The Chinese are by far the most likely to accept evolution with no involvement of a God (67%), it being next most common amongst Mexicans at 42%. This could be because the political development of China has been influenced by Darwinian theory (Butt, 2009b; Pusey, 1983) and the vast majority of the Chinese population (81%) claim no religious affiliation (Pew Research Center, 2008). Scarcely anyone in Egypt (2%) or South Africa (6%) endorsed this view.

The countries where creation by a God in its current form predominated were Egypt (50%), India, South Africa and the USA (all at 43%). A majority in each of these countries follows a religion that promotes an alternative explanation to Darwinism. Figures show that 95% of Egyptians are Muslim (Pew Research Center, 2009a) and 76% of Americans claim to be Christian (nearly half being evangelical or born again) (Kosmin & Keysar, 2009). According to the Government of India (2001), 81% of Indians are Hindu. The South African census shows 84% follow a religion, mainly a variety of Christian denominations (Statistics South Africa, 2001). By contrast, just 7% of Chinese people took the creationist position.

It is notable that roughly a quarter of South Africans (26%) did not express a view in response to this question. This could be due to ignorance of evolutionary theory: it was absent from the curriculum pre-1994 (Section 3.1.3) and elsewhere in the British Council survey 73% of South Africans said they had never heard of Charles Darwin.

<u>Table 4.3: Views about life on earth (international figures)</u>

Country	Sample size	Evolution without God (%)	Evolution + God (%)	God without evolution (%)
Argentina	1000	37	31	19
China	1048	67	10	7
Egypt	1277	2	33	50
GB	973	38	25	16
India	909	20	32	43
Mexico	1012	42	27	25
Russia	1600	32	24	13
South Africa	2000	6	21	43
Spain	958	38	18	18
USA	991	13	32	43

Source: British Council (2009)
Base: respondents aged 18+

Miller et al. (2008) compared data from a survey in the US with data derived in a similar way from Japan and 33 European countries. Respondents were presented with the assertion “Human beings, as we know them today, developed from earlier species of animals”. In the US in 2005, almost identical percentages accepted (40%) and rejected (39%) the idea. Only Turkey showed greater rejection of evolutionary theory than the US (around 50%). The UK had the highest levels of acceptance of evolution along with several Nordic nations plus France and Japan.

4.2 Religious perspectives on evolution

The thesis concentrates on the Christian and Muslim faith traditions, which will also form the focus of this section. Moreover, the Church of England and Roman Catholic positions will be given particular emphasis as they constitute 55% and 19% respectively of adult Christians in the UK (Ashworth & Farthing, 2007). The pronouncements on evolutionary theory from representatives of the religions or denominations will be explored, but there is of course no guarantee that such views are shared by all adherents.

The Church of England has no official position on evolution, but its head (the Archbishop of Canterbury) touched on the issue in a 2006 interview with the Guardian newspaper. He stated that he did not agree with the teaching of creationism in schools, as biblical writings could not be considered on the same terms as scientific theories (Guardian, 2006). The Church of England created a new section of its website in the run-up to Darwin's bicentenary. This included an article that was broadly supportive of his theory but critical of those Social Darwinists who had distorted it to lend support to racist and other discriminatory positions (Brown, n.d.). Brown concludes by issuing an apology to Darwin on behalf of his Church for its original response, which he blames for ongoing misinterpretation of the theory.

The stance of the Roman Catholic church was set out in a papal encyclical of 1950 (Pius XII, 1950). In it, there was acceptance that bodily evolution was a scientific possibility worthy of exploration, but that the human soul was created by God. Almost 50 years later, Pope John Paul II recognised that more evidence had come to light in support of Darwin's theory but he reinforced the earlier view that the soul was not a product of evolution and theories that claim otherwise should be rejected: "theories of evolution which, in accordance with the philosophies inspiring them, consider the mind as emerging from the forces of living matter, or as a mere epiphenomenon of this matter, are incompatible with the truth about man" (John Paul II, 1996, paragraph 5). Benedict XVI (pope at the time of writing) said in an audience in Auronzo di Cadore (Libreria Editrice Vaticana, 2007):

> Currently, I see in Germany, but also in the United States, a somewhat fierce debate raging between so-called "creationism" and evolutionism, presented as though they were mutually exclusive alternatives: those who believe in the Creator would not be able to conceive of evolution, and those who instead support evolution would have to exclude God. This antithesis is absurd because, on the one hand, there are so many scientific proofs in favour of evolution which appears to be a reality we can see and which enriches our knowledge of life and being as such. But on the other, the doctrine of evolution does not answer every query,

> especially the great philosophical question: where does everything come from? And how did everything start which ultimately led to man? (paragraph 12)

There is a paucity of published work examining views among Christian clergy. One survey in the US suggested that most of them accepted evolution, were prepared to accept a non-literal and therefore non-conflicting interpretation of the Bible, and thought creationism should not be taught in schools (Colburn & Henriques, 2007). The authors claim the findings represent those of “a large subgroup” of Christian clergy. However, the sample was drawn from a local ecumenical organisation and therefore subject to potential bias in terms of geography and religious framework (for instance, their involvement in ecumenism might imply respondents would be less likely to be biblical literalists). Moreover, the response rate for this postal survey was only one in three and no attempt was made to establish whether these 53 respondents were representative of the total clergy approached.

Islam does not have the same hierarchical structure as the Anglican and Catholic churches, so an official position on the subject cannot exist in the same way. Writings of Islamic scholars, theologians and scientists show that, as in other faith traditions, there are a number of possible viewpoints along the spectrum from acceptance of Darwin’s theory to outright rejection. Nasr (2006), Professor of Islamic Studies at George Washington University, does not personally accept evolution. He claims that “no Muslim would say there is no Hand of God involved” (p. 232). He dismisses any theistic interpretations, saying they fail to have even scientific respectability because they have introduced a supernatural dimension.

According to Iqbal (2009), the Islamic response to evolution is linked to relations with Western colonial powers and consequent attitudes to Western science. As modern Muslims are increasingly involved in education that is based on Darwinian theory, a majority accepts evolution despite Qur’anic proclamation of the fixity of species (Iqbal, 2006). However, data from the general public do not endorse his view. International comparisons consistently show Islamic majority countries such as Egypt and Turkey have the lowest percentage accepting evolutionary theory (British Council, 2009; Miller et al., 2008). A similar picture emerges where Muslim respondents are analysed separately in Western surveys. Evolution tends to be chosen as the explanation of life on earth by around 10% or less: the most popular option is sudden creation by God; the second most popular is intervention by a supernatural being (eg Lawes, 2009; Opinionpanel, 2006). According to Deniz, Donnelly and Yilmaz (2008), Muslims find Darwinism incompatible with their beliefs because the Qur’an states there is a purpose to the creation of the universe and living things, whereas evolution by natural selection is not a goal-directed process.

4.3 Scientists' perspectives on evolution

The Pew Research Center (2009b) asked US scientists how they thought life on earth had come about, and put the same question to members of the public. As shown in Table 4.4, most scientists (87%) attributed it to evolution by natural processes, compared with only 32% of the public. Just 2% of scientists, rising to 33% of the public, thought humans and other living things had always existed in their present form. It should be noted that the figures for the public show more opting for evolution and fewer for creationism than the surveys in Table 4.2; however, as the same question was posed to scientists the two sets of figures can be compared. Sub-totals do not necessarily sum to the total, nor the columns to 100%, because not all answer options are shown.

Table 4.4: Views on evolution – scientists versus public (US)

Sample size: Humans and other living things have ...	Scientists 2533 %	Public 2001 %
... evolved over time (total)	97	61
... evolved over time due to natural processes	87	32
... evolved over time guided by supreme being	8	22
... existed in their present form since the beginning of time	2	31

Some more detailed but smaller scale interview studies have been conducted among practising scientists. Based on 20 Australasian-based scientists who currently followed a religion or had done in the past, Coll, Lay, and Taylor (2004) claim that scientists are less dogmatic when weighing up evidence claims in science and religion than students and the wider public imagine. When dealing with dissonance, some privileged religious over scientific views and some did the reverse; others compartmentalised the two to avoid conflict.

In another study, this time amongst 17 US scientists and science educators, Meadows, Doster and Jackson (2000) investigated approaches for dealing with conflict between science and religion as exemplified by evolution, and found similarities to the findings reported by Coll et al. (2004). Some participants were unaware of, and therefore untouched by, any conflict. Others avoided the issue by compartmentalising their scientific and religious beliefs. A third category acknowledged the conflict and were uncomfortable about it because of their inability to resolve it. The final group had developed personal theories to manage the conflict by accepting certain elements of the religious and scientific views, although some problematic areas, such as human evolution, might remain.

These two studies, albeit restricted in size, demonstrate the individualistic nature of the response to the topic.

Studies such as those by Coll et al. (2004) and Meadows et al. (2000) serve to highlight again the importance of the inter-relationship between science and religion in attitudes towards evolution. Even among professional scientists who work in the field of evolution there is no consensus about how the two might or might not interact. On the contrary, their views range across a wide spectrum (Barbour, 2000; Haury, 2007; Ruse, 2006). This is illustrated by mapping some eminent biologists onto Barbour's fourfold typology (Barbour, 2000), outlined in Section 2.3. Outspoken atheists such as Richard Dawkins and E. O. Wilson would fall into the category of conflict; Stephen Jay Gould was a proponent of independence; and evolutionary scientists such as Dobzhansky and Conway Morris represent those whose approach is characterised by dialogue or integration.

The geneticist Francisco Ayala believes that to improve scientific achievement in the US it is imperative for American scientists to convince people that science and religion are not in opposition, otherwise "students assume that if they get involved in science courses, teachers will attempt to destroy their religious beliefs" (Easterbrook, 1997, p. 890).

There is little published survey research on the religious beliefs of scientists. What there is confirms the view that scientists are less likely than the general public to have religious beliefs. Although Anderson (2007) claims that several surveys indicate that around 4 in 10 scientists are religious, his one supporting reference (Easterbrook, 1997) cites only a study by Larson and Witham (1997). They found that 39% of US scientists believed in a personal God, 45% did not, and the remainder was undecided (based on a random sample of around 600 scientists). A survey by The Pew Research Center (2009b) showed that 33% of US scientists believed in God (higher among chemists than biologists or physicists), 18% in a higher power, and 41% in neither. Equivalent figures for the US public at large were 83%, 12% and 4% respectively, showing that they were well over twice as likely to have a belief in God. Similarly, whereas only 48% of the scientists said they have a religious affiliation (albeit notably more than profess to believe in God), this rose to 82% of the wider population (Pew Research Center, 2009b).

Some studies have claimed that levels of atheism increase with scientific eminence (Larson & Witham, 1998) or amount of training (Falcão, 2008). Larson and Witham posed their question about belief in a personal God to "leading" scientists (those belonging to the National Academy of Sciences, where membership is by invitation only). This showed

72% disbelief compared with 45% in their previously reported wider sample of scientists (Larson & Witham, 1997). Similarly, a study of university scientists in Brazil and the UK concluded that more highly trained scientists were less likely to have a religious belief (Falcão, 2008). However, there is no convincing evidence of cause and effect. The relationship could be a function of age rather than experience (as they tend to be closely correlated) and the Pew Research Center (2009b) found that belief in God was lower among older scientists.

4.4 Teaching the origin of life

Several of the public surveys have included questions about respondents' views on the teaching of evolutionary theory and its alternatives in school science. The most popular stance is that evolution should be one among several explanations presented. This was true for all but one of the countries in the British Council (2009) survey. Spain was the exception: here the teaching of evolution in isolation was narrowly ahead. Just over half (54%) the British public thought a range of explanations should be taught, with 21% opting for evolution only compared with 9% thinking evolution should not be covered at all. For the US, the first two figures were very similar (51% and 21%), although over twice as many (21%) were of the opinion that evolution should be excluded altogether. In general, respondents who claimed to know more about evolutionary theory were more likely to support its teaching in school science (either on its own or alongside other explanations).

A question arising from such surveys is how influential the public position on teaching different explanations of the origin of life in school science should be in determining the curriculum. Pennock (2007) is adamant that it would be inappropriate to allow public opinion to decide such matters.

Some small-scale but in-depth studies of teachers have concluded that their worldviews and beliefs, particularly as regards religion, interact with their knowledge and can affect their teaching. For instance, Science teacher narratives collected from very different populations – 4 Anglo-American high school teachers in Arizona, USA (Cobern & Loving, 2000) and 10 Sunni Muslim preparatory school teachers in Egypt (Mansour, 2008) - illustrate that there is no single standard scientific worldview. Moreover, different individual conceptions influence the way science is presented to students. This makes it an important area for investigation.

Although they have to operate within the constraints of the curriculum, in the final analysis, it is the teacher in the classroom who determines what is taught. Teacher judgement may also be questionable. Several authors have identified a link between teachers' understanding and personal views on a topic and their coverage of it in the classroom (Moore & Kraemer, 2005; Rutledge & Warden, 2000).

A number of studies have been conducted to examine the relationship between teachers' viewpoints about evolution and their instructional practice. Most of these have emanated from the US, where there is particular concern that teachers who dispute the validity of the theory might deliberately avoid teaching it.

Surveys in various US states have found that acceptance of evolution among biology teachers, whilst not unanimous, is much higher than among the general public, at around two-thirds to three-quarters of the sample (Rutledge & Mitchell, 2002; Tatina, 1989; Zimmerman, 1987). According to several studies, teachers who accept evolutionary theory are more likely to spend time teaching it in their classrooms (Rutledge & Mitchell, 2002; Trani, 2004; Zimmerman, 1987). Tatina (1989) did not find this correlation among biology teachers in South Dakota. However, he did find a link with the likelihood to teach creationism - it was more likely to feature in classrooms where the teacher rejected evolution and less common where the teacher accepted evolution.

In a national survey of 926 US high school biology teachers, Berkman and Plutzer (2011) found that nearly four in 10 teachers in the most socially conservative school districts, compared to 11% in the least conservative, did not accept human evolution. Just over a quarter (28%) of all the teachers said they followed national guidelines on teaching the theory of evolution, including its supporting evidence and over-arching relevance for biology. On the other hand, 13% spent teaching time presenting creationism or intelligent design in a favourable way, and another 5% responded positively if such ideas were raised by students.

The remaining teachers are described as "the cautious 60%" who are active supporters of neither evolution nor creationism. To reduce potential confrontation, the teachers avoid teaching macroevolution or find strategies to lessen its impact. For instance, they explain they are only teaching it for the state tests or they teach it in the context of alternative explanations. Berkman and Plutzer (2011) argue that by failing to explain scientific inquiry and by challenging expert authority these 60% are more of a threat to scientific literacy than the obviously creationist teachers, and their approach inadvertently legitimises the creationist position. They recommend paying more attention to pre-service teachers and making a course in evolution compulsory for everyone to increase knowledge, understanding and confidence in the topic.

A survey of pre-service elementary teachers doing a basic science course in Canada (Asghar et al., 2007) showed a similar level of acceptance of evolutionary theory as in the US studies (71%), and there was a statistically significant relationship between accepting it and teaching it.

Perhaps unsurprisingly, there is evidence that the strength of teachers' religious convictions is correlated with their acceptance of evolution: those with stronger beliefs are more likely to reject the theory (Rutledge & Mitchell, 2002; Trani, 2004). Trani found this negative correlation (r=-0.80) to be significant at the 0.05 level. He also found significant negative correlations between rejection of evolutionary theory and both teachers' understanding of evolution and their likelihood of covering it in the classroom.

As part of the Biohead-Citizen project, funded by the European Union to examine how biology, health and environmental education can help promote better citizenship, teacher attitudes to evolution were compared across 19 countries (Clément, 2008). Teachers were asked to choose which of the following four statements they most agreed with (Clément & Quessada, 2008, translation from French):

- the origin of life is definitely the result of natural phenomena;
- the origin of life might perhaps be explained by natural phenomena without any intervention from God;
- the origin of life might perhaps be explained by natural phenomena that are under the control of God;
- it is certain that God created life.

In 11 of these countries, biology teachers were more evolutionist than other teachers (usually through greater endorsement of the statement related to natural phenomena and God acting together), but in the remainder there was no significant difference.

The percentage of creationist teachers was highest in the five majority Muslim countries, but none of these was in Europe (Clément & Quessada, 2008). To try and tease out the effect of culture rather than religious faith, the authors compared data for Christians in France with Christians in two non-European countries where the sample size permitted (Lebanon and Burkina Faso). This revealed that even when limiting the analysis to Christians, there were more anti-evolutionist views in the non-European countries. It seems that a combination of potentially inseparable factors – less developed countries with heavily embedded religious practices, a lack of evolution in schools but a strong tradition of religious education (in or out of school) – leads to a pro-creationist influence.

Inadequate knowledge and understanding of evolutionary theory and of science more generally has consistently been shown to play a role. Research suggests that teachers who have a more impoverished appreciation of the nature of science and status of scientific theories, and a poorer grasp of evolutionary concepts, are less likely to accept the theory (Lombrozo, Thanukos, & Weisberg, 2008; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Trani, 2004). Inadequate understanding is widespread: for instance, in-depth interviews among elementary teachers (Asghar et al., 2007) failed to find any with a full appreciation of the scientific concept of evolution. Clément (2008) found a statistically significant relationship between teachers' broad educational level and their view of origin of life. Controlling for any effect of country or religion, those with more years at university were more likely to accept evolution.

Such findings have led several authors to conclude that the provision of better training and support for Science teachers is critical. Moore and Kraemer (2005) asked biology teachers whether their undergraduate methods class had prepared them adequately to teach evolution and just over half (52%) felt that it had not. Unfortunately, no comparison with any other biology topic was sought. It is recommended that training should cover a number of aspects: content knowledge and understanding of evolution; understanding of the nature of science; and guidance on dealing with challenges from anti-evolutionists (Asghar et al, 2007; Cleaves & Toplis, 2007; Griffith & Brem, 2004; Rutledge & Mitchell, 2002).

Berkman and Plutzer (2011) suggest that, by making a course in evolution mandatory for preservice teachers, those who cannot accept the theory will be deterred from becoming teachers. Long (2012) questions whether, given the American stance on freedom of religious expression and separation of the church and state, this type of approach is ethical.

4.5 Summary

In its examination of views about the origin of life among different groups, this chapter has highlighted the complexity of the issue. Firstly, findings are highly dependent on exactly how opinion is measured. For instance, whether the question used the wording "evolve" or "develop", or referred to "all living things" rather than "human beings", was shown to have a considerable effect on the outcome. These are matters to be sensitive to when designing research instruments. Secondly, viewpoints are influenced by a number of factors which are difficult to disentangle, including religious adherence, cultural background and educational level.

There is a split in public opinion about the validity of evolutionary theory, and this varies by country. Surveys show that the UK is much less creationist in outlook than the US, although even here a significant minority reject the theory. Public pronouncements by the two main Christian denominations in the UK (Church of England and Roman Catholic) tend to be broadly supportive of evolution. Although there is a spectrum of opinion among Muslims, they are generally less favourable towards the theory and populations in countries with an Islamic majority, such as Egypt and Turkey, are more likely to take a creationist position.

Whilst a clear majority of scientists accept evolutionary theory, this does not mean that they are an irreligious group. Although they are less likely than the general public to believe in a God, the limited research available suggests that around four in ten US scientists do so. Qualitative research shows that they have used different techniques to reach an accommodation between an acceptance of evolution and their religious belief.

Surveys suggest that members of the public in several countries favour the teaching of alternative explanations of the origin of life in science classrooms. However, it is the teacher who is ultimately responsible for what is covered in lessons, whatever position parents, politicians or science educators may take. There is evidence – particularly in the US – that some teachers avoid teaching about evolution because of their religious beliefs or their lack of confidence either with the subject content or its perceived controversial nature. There is general agreement that better training – to improve understanding of evolutionary theory and the nature of science, as well as how to deal with challenges from those opposed to evolution as a concept – would have a beneficial effect on its teaching in diverse classrooms. The research question *What are Science and RE teachers' opinions about teaching scientific and religious explanations of the origin of life?* is relevant to help assess current attitudes and concerns amongst teachers.

5. Implications for the classroom

This chapter looks at the coverage of the origin of life in schools against the backdrop of the desire to create scientifically literate citizens. It explores evolutionary theory as an example of a controversial issue and an illustration of several aspects of the nature of science. Literature about the sociology of the curriculum and the implications of cultural differences between home and school is examined.

5.1 Evolution in science education

5.1.1 The goals of science education

Issues around the purpose of the science curriculum and the increased emphasis on scientific literacy have already been discussed (Section 3.3.1). This focus on producing more scientifically literate citizens sits within a general context of Western countries nurturing a better informed public to encourage greater participation in a more effective democracy. Instrumental in achieving this broader ambition is education for different types of literacy including civic (Milner, 2002); media and digital media (Kellner & Share, 2007; Rheingold, 2008); health (Nutbeam, 2000); and mathematical (Jablonka, 2003).

Education for scientific literacy has substantial historical roots, but it has gained international prominence over the past 15 years or so with the promotion of the science education for citizenship agenda (Bybee, 2010; Hurd, 1998; Laugksch, 2000; Millar & Osborne, 1998). There is no single agreed description of scientific literacy (Laugksch, 2000; Ratcliffe and Millar, 2009). However, Ratcliffe and Millar distil three common elements that run through its many definitions which should therefore be present if curricular outcomes are successful. These are: some knowledge of science concepts and ideas; some understanding of the inquiry process and the nature of resultant knowledge; and an appreciation of the influence of society on science and vice versa.

A report to the Nuffield Foundation (Osborne & Dillon, 2008) concludes “The primary goal of science education across the EU [European Union] should be to educate students both about the major explanations of the material world that science offers and about the way science works” (p. 8). Longbottom and Butler (1999) link science education with facilitating a democratic society by empowering citizens. For them, the three aims of science education are to teach children that scientific knowledge is reliable but not infallible; to endorse the validity of paying attention to expert opinion albeit maintaining a healthy scepticism; and to foster in them the ability to examine evidence rationally and creatively. DeBoer (2000) lists nine goals of science teaching, including creating informed citizens who are aware of contentious issues and capable of exploring them independently, and enabling the appreciation of the nature of science in terms of methods, evidence and data.

Some of the lists of science education goals include reference to gaining an appreciation of where science has legitimate jurisdiction. Osborne & Dillon (2008) talk about developing "some understanding of both the strengths and limits of science" (p. 8). For DeBoer (2000), students should be made aware of where it has no dominion (for him, the emotional and spiritual spheres). Similarly, Longbottom and Butler (1999) explicitly stop short of endorsing the relevance of science to wider issues including religious ones.

It is against this backdrop of a focus on scientific literacy that the teaching of evolution takes place. It links with many of the aims of contemporary science education detailed above: it represents a key biological concept and its study can demonstrate the importance of data collection, evidence and the interaction of society and science. However, as has already been outlined (Chapters 3 and 4), acceptance of evolutionary theory is far from unanimous.

5.1.2 Teaching evolution: understanding versus acceptance

The subtleties of language form a recurring theme in this area of the literature and merit some attention here before taking the discussion forward. Much of the debate revolves around the definition of two key concepts: belief and acceptance. Sinatra, Southerland, McConaughy and Demastes (2003) neatly outline the distinction between the two and, except when quoting participants' own language, this thesis follows the same guidelines:

> [...] it is inappropriate to suggest that a scientist believes in evolution, as is often explained by the layperson, as believe implies that the judgment of the validity of the theory is based on personal convictions, opinions, and degree of congruence with other belief systems. This use of ''belief'' has the potential for blurring the distinctions between scientific knowledge and religious belief. [...] Instead scientists accept evolutionary theory as the best scientific explanation currently available based on a systematic evaluation of the evidence. (p. 512)

Elsewhere, some disparity is evident between different authors. Earlier studies in particular tend to refer exclusively to "belief" in evolution (for example, Lawson & Weser 1990; Lawson & Worsnop 1992; McKeachie, Lin & Strayer, 2002; Meadows et al., 2000). Occasionally the terms belief and acceptance are used interchangeably (see, for instance, Cavallo and McCall, 2008) which leads to ambiguity and a blurring of meaning.

Scharmann (2005) stresses the importance of teachers' use of language. He dismisses "belief" in evolution as irrelevant to teaching it and an unsuitable word in the science classroom. Hermann (2008) takes a similar stance and postulates that academic authors who default to "belief" are reflecting the language used by research participants. Although Williams (2009) recommends that teachers discuss acceptance rather than belief as one way of helping to counter creationism, even he occasionally fails to distinguish clearly between the two.

That said, there is widespread debate about whether it is sufficient for students to gain knowledge and understanding of evolutionary theory or whether Science teachers should be persuading them to accept it as the most convincing explanation for the origin of species (Cobern, 2004; Ingram and Nelson, 2006; McKeachie et al. 2002; Smith & Siegel, 2004). The majority view among educators seems to be that achieving understanding is more appropriate and much less problematic than aiming for acceptance (Anderson, 2007; Clough, 1994; Ingram and Nelson, 2006; Meadows et al., 2000).

Some literature advocates the explicit discussion of beliefs in the science classroom. For instance, although Cobern (1994) acknowledges that conceptual understanding should be the main goal of science education, he argues for a cultural constructivist approach where students discuss the believability of evolution before tackling understanding. Ha, Haury and Nehm (2012) suggest that as well as exercising care in the use of language, teachers should compare the meaning of “belief” in science with other contexts.

For pragmatic reasons, in the view of Anderson (2007), all a teacher can realistically achieve in the classroom is to impart and test knowledge. But because he operates in the US, where the proportion of students with religious belief is high, he recognises the importance of eliciting their broader views on the issue and supporting them as they explore their understandings. Meadows et al. (2000) conclude that the most productive approach for teachers in the classroom is to aim for helping students to manage their personal beliefs in relation to evolution, rather than attempting to change them.

Mike Smith and Bill Cobern have engaged in a long-running debate about the distinction between knowledge and belief and their relevance in teaching science and, particularly, evolution. Cobern (1994) contrasts the viewpoint of scientism (evolution directly represents reality so it is not subject to belief systems but can only be understood) and constructivism (evolution is currently the best explanation science has, thus representing a belief that is subject to doubt). Whilst Smith (1994) agrees that students’ cultural backgrounds and worldviews are important to consider initially, he maintains that Cobern’s emphasis on belief risks blurring the distinction between faith or opinion and scientific acceptance. Ten years later, Smith and Siegel (2004) proposed that in situations where students do not accept evolution, the priority should be to persuade them that, of all available scientific explanations, it is the best. In response, Cobern (2004) reiterates that belief and knowledge can be treated as the same thing because they have a common form: he agrees that it is possible to differentiate between the two but argues that it is not pedagogically advantageous. This seems slightly at odds with his assertion elsewhere in the article that it is important to teach students what constitutes a scientific question.

McKeachie et al. (2002) claim that most biologists and teachers would want students to “believe in” evolution rather than just understand it. They suggest that citizens who fail to accept the theory may prove unwilling or incapable of taking an informed role in society when biological issues are debated. Lombrozo et al. (2008) take a similar stance, concluding that teaching for belief is necessary if evolutionary knowledge is to improve the decisions students take about the way they live. Blackwell, Powell and Dukes (2003) report their intervention to tackle student acceptance of evolution with the proviso that it is designed not to “impose knowledge and belief on the student” but in the hope they will “naturally incorporate at least some of the ideas of evolution into their own belief system” (p. 58). Despite their protestations, the authors seem to assume that any worldview which does not incorporate evolution by natural selection is in need of correction.

5.1.3 The implications for academic success of rejecting evolution

Some authors claim that acceptance of evolution is a necessary prerequisite for gaining a sound knowledge of the theory and a thorough understanding of its processes. Consequently, it would have an adverse effect on the academic performance of those who reject it (Deniz et al., 2008; Lawson, 1983). The evidence for this, which mostly emanates from research among university students, is mixed.

Data from a study of students on an introductory college biology course in the American Midwest support the contention that acceptance and performance are positively correlated (McKeachie et al., 2002). It concluded that those who believed in creationism achieved poorer final course grades than their colleagues who accepted evolution. An increase in acceptance of evolution was also recorded among those completing the course. However, drop out from both the course and the survey was so high (and furthermore, weighted towards rejecters of evolution) that they ended up with a small, skewed sample (28 out of the original 60, including just three creationists) and no robust data. In a larger study, Deniz et al. (2008) looked at 132 pre-service teachers in Turkey. They used a convenience sample but give no details of how participants were chosen, so it is unclear what inherent biases there may have been. Using recognised measures of content knowledge and acceptance of evolution, they found a statistically significant positive correlation between the two ($r=0.2$, $p<0.05$), ie someone who understood the theory better was more likely to accept it.

In contrast to those results, a number of studies have failed to find a link between levels of understanding and acceptance of evolution (Bishop & Anderson, 1990; Demastes, Settlage & Good, 1995; Lawson & Worsnop, 1992). Sinatra et al. (2003) found no relationship between the likelihood to accept animal or human evolution and the level of content knowledge when they investigated 93 college undergraduates on a non-majors' biology course. Content knowledge was assessed using written justification as well as multiple choice, making it arguably more sophisticated than that used by Deniz et al. (2008), for instance, which used forced choice answers only. However, acceptance was based on participants assessing the credibility of magazine articles presenting a "controversial application" (p. 516) of evolutionary theory – evolution of flight in birds and the role of meat eating in brain size development of early humans. The validity and reliability of this technique was not reported, whereas the measure of acceptance of the theory of evolution (MATE) used by Deniz et al. had previously been assessed for content validity (Rutledge & Warden, 2000) and achieved a high reliability score (Cronbach's alpha of 0.94).

Although Ingram and Nelson (2006) did not find a strong link between students' initial acceptance of evolution and their subsequent course grades, there was a limited positive correlation between post-course acceptance and achievement. They also found a small overall increase in positivity about evolution after the course, in contrast with other studies (Bishop & Anderson, 1990; Lawson & Worsnop, 1992). They hypothesise that this resulted from the greater intensity of their course (a semester-long majors course with an evolutionary focus).

Taken as a whole, these studies are unconvincing and even confusing. There seem to be several possible reasons for this. It could be related to the research population (size and nature of the sample, including the age of the students and their science knowledge); the courses undertaken (ranging from a single session to several weeks, with different degrees of focus on evolution); and the research instruments and methods used.

Ha et al. (2012) were conscious of the unsatisfactory situation regarding the quality of the psychometric instruments when conducting their study to examine relationships between factors including knowledge and acceptance of evolution. They used two widely recognised measures of knowledge with reasonable reliability scores (Cronbach alphas over 0.7). For acceptance, they administered the MATE and achieved a Cronbach's alpha of 0.94. Their findings, based on 124 pre-service biology teachers in South Korea, showed a low but significant correlation between the knowledge and acceptance scales. A crucial part of the study was to ask participants to gauge their certainty that each of their content knowledge answers was correct using an 11-point scale. The level of certainty was found to be significantly positively correlated with both acceptance and knowledge of evolution. Ha et al. describe the feeling of certainty as a measure of intuitive cognition rather than logic, but this seems questionable. If participants are expressing their certainty about their answers, this could be a logical assessment of confidence level and merely another conscious measure of knowledge rather than anything intuitive. The authors argue that if an intuitive feeling of uncertainty conflicts with a sound knowledge, this will impinge on acceptance of evolution in a way that explains the inconsistent pattern of the relationship between acceptance and knowledge seen in previous studies (see above). However, they do not present enough evidence to support their claim of the intuitive nature of the feeling of certainty.

In summary, research into the relationship between understanding and acceptance does not allow any definite conclusions to be drawn. It is interesting to note that research into the over-arching relationship between achievement in school science and attitudes to the subject as a whole is also fairly inconclusive (Osborne, Simon & Collins, 2003).

5.1.4 Is the origin of life a controversial issue?

For many involved in science education, the evolution/creationism debate constitutes an example of a controversial socio-scientific issue. Others hold the opinion that it should not be treated as such because the vast majority of scientists accept evolutionary theory and therefore it is non-negotiable in a scientific context. In this dispute, two defining characteristics of socio-scientific issues are relevant: that they are based in science and that typically they are controversial (Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006; Zeidler & Nichols, 2009).

Wellington (1986) defines a controversial issue as one that involves value judgements rather than just a reliance on facts or experiment. Moreover, a significant number of people must consider it important.

In his introduction to a book edited by Dana Zeidler on moral reasoning and socio-scientific issues, Lederman (2003) maintains that the debate about evolution and creationism fails the criterion of being scientifically-based, on the grounds that it “is not really the result of the development of scientific knowledge” (p. 3). Scott and Branch (2003) also allude to consensus in the scientific community when dismissing calls to “teach the controversy” in the science classroom. Recognising that students might not “draw sharp disciplinary boundaries” (p. 502), they acknowledge that a possible method of dealing with this is for Science teachers to explicitly mention the controversy but explain that it is not within the scope of their lessons. They concede that it might be appropriate to cover it in other subjects, such as history or comparative religion. In contrast, Pennock (2002) thinks creationism has no place anywhere in state schools, because it has no evidentiary support. He rejects the position that the debate between creationism and evolution might hone students’ thinking skills as needlessly time-consuming.

However, the weight of opinion seems to be that evolution is controversial and does qualify as a socio-scientific issue. This is crystallised by other contributions to the Zeidler (2003) book mentioned in the previous paragraph. In direct contradiction to Lederman's negation of evolution as a socio-scientific issue in the book's introduction, several authors cite it as a useful example of one: Bell (as an opportunity to explore what is meant by a scientific theory); Loving, Lowy, and Martin (as a diversity-related, ethical problem); and Berkowitz and Simmons (as a controversial topic).

Hermann (2008) acknowledges that the controversy over evolution is of a cultural nature and most scientists find it uncontentious. Nevertheless, in his view, it fulfils the four essential criteria that make a topic controversial: there are distinct opponents; they are locked in impassioned disagreement; debate is not confined to an unreasonable fringe; and the knowledge and evidence base is disputed.

Levinson (2006) also considers evolutionary theory to be controversial. He postulates that a number of criteria underpin the controversy, including "people start from different premises, hold different key beliefs, understandings, values, or offer conflicting explanations or solutions that are rationally derived from the premises" and "a substantial number of people or different groups" are involved (p. 1204). In his typology of levels of disagreement, Levinson places fundamental creationists and evolutionists in the most extreme category. According to him, there is minimal chance of reaching resolution through the use of evidence, because the opposing parties are basing their arguments on different truth criteria. Consequently, Levinson is pessimistic about the chances of constructive dialogue and suggests the most likely outcomes are continued clashes of opinion, agreement to disagree, or a complete breakdown in communication.

The debate over evolutionary theory also fits very well with some of the key criteria of controversial issues outlined by Oulton, Dillon, and Grace (2004). These include: groups hold contrasting views about an issue either because they are not using the same information or are interpreting it differently; the interpretations may vary because they are based on diverse worldviews which come from different value systems; and the issues cannot always be sorted out through a call to reason, logic or experimentation.

If it is agreed that the origin of life constitutes a controversial issue, excluding this perspective on it from the curriculum has important implications. Wellington (1986) outlines three main justifications of including areas of controversy. Two are content related: education is incomplete without addressing such significant matters, and a discipline is misrepresented if its contentious elements are ignored. Wellington singles out Science teachers as the worst offenders in presenting their subject as "unproblematic, value free and non controversial" (p. 3). This is the kind of criticism the curricular focus on how science works is designed to counteract (Section 3.3.1). The third reason for inclusion relates to developing student ability to gather and assess evidence, look at validity and possible bias of sources, and come to informed conclusions. Furthermore, this process gives the opportunity to improve communication, listening and collaborative working skills.

Nord (1999) calls for evolution to be taught to students as a controversial issue which has broader relevance: “Our ongoing cultural conversation about the relationship between science and religion is much more interesting than most educators appreciate, and it strikes me as scandalous that we don’t let students in on this conversation” (p.33).

5.1.5 Teaching evolution as a controversial issue

The thrust of the previous subsection is that there are compelling arguments for treating the origin of life as a controversial issue. The raises the question of how best to address it in the classroom.

To create an open and democratic forum, Harwood (2001) recommends that the teacher favours the position of impartial facilitator – not expressing a personal viewpoint but chairing discussion in a way which allows student voice to predominate. However, the teacher would be flexible enough to adopt different roles as circumstances demand. Harwood describes a hierarchy of preferred roles that careful planning and empathy for the students allow teachers to move through as and when required. For instance, where teacher input is unnecessary they could become an non-participating observer, or if their presence is not needed at all, an absent leader. In contrast, when greater guidance is appropriate, they could become instructor (providing information, assessing understanding and giving feedback) or devil’s advocate to provide ideas and stimulate discussion.

Hermann (2008) stresses the importance of presenting evolutionary theory in a non-threatening way to encourage participation from some students who would otherwise fail to engage with it. He considers four possible teaching strategies: procedural neutrality (teacher uses resource materials to draw out views from students – similar to impartial facilitator described in the previous paragraph); affirmative neutrality (teacher inputs different views); advocacy (teacher elicits student views but presents the scientific perspective as the only correct one); and avoidance (teacher fails to cover evolution because of their own lack of acceptance, concern to avoid controversy, or inadequate training). Hermann criticises affirmative neutrality as being limited by what the teacher chooses to consider, and advocacy as failing to account for the controversial nature of the topic because its goal is conceptual change. His personal preference is for procedural neutrality whereby students gather their own information rather than relying on the teacher. Acknowledging the difficulty of showing the effectiveness of this approach, Hermann argues that it might be judged not by knowledge gains but by its success in reducing student discomfort and promoting understanding towards other views. Procedural neutrality has been endorsed by many other educators (Bridges, 1986; Reiss, 2008b). Others criticise it for silencing the most informed person in the classroom and being challenging for the teacher to maintain (Ashton & Watson, 1998; Oulton et al., 2004).

The evolution course developed by Ingram and Nelson (2006) abandons a lecture-based approach for constructivist strategies. Rather than directly challenging students' religious beliefs and doubts about evolution, it provides opportunities for problem-solving and examining the evidence (such as comparing skull morphology). Ingram and Nelson find that even though some students persist in holding a creationist view of origins after the course, several of them answer supplementary questions in a fashion consistent with evolution. They argue that this may be due to either a lack of critical thinking or the development of a more refined theological position. Long (2012) disagrees with this reasoning, suggesting it merely reflects the proficiency of creationist students in anticipating what test responses the system expects and hiding their true beliefs.

5.1.6 Understanding Nature of Science and the theory of evolution

The growth of concern about creationism in UK schools has coincided with increased emphasis on the nature of science - an attempt to explore its underlying values and assumptions (Section 2.2.1). McComas, Clough, and Almazroa (1998) have described the nature of science as offering "a rich description of what science is, how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavours" (p. 4). Influential documents have successfully argued that the nature of science should become a fundamental part of science education in the UK (House of Commons Science & Technology Committee, 2002; Millar & Osborne, 1998) and it has grown more prominent in school curricula across the globe (Lederman, 2006; Matthews, 2009). It has also been suggested that a better understanding of the nature of science would foster a more positive relationship between attitudes to science and religion (Astley & Francis, 2010).

Evolutionary theory is widely recognised as providing an ideal illustration of various aspects of the nature of science (Cavallo & McCall, 2008; Clores & Limjap, 2006; Hermann, 2008; Nelson, Nickels & Beard, 1998). It exemplifies the process by which many new scientific theories struggle for and finally gain acceptance; demonstrates that scientific knowledge is tentative; underlines the importance of weighing the evidence; and illustrates the properties of falsifiability and predictive power in coming to conclusions about the acceptability of a theory. In the US context, Anderson (2007) stresses that the teaching of evolutionary theory needs to be embedded within an understanding of the nature of science, because the majority of students have a theistic outlook and are less concerned with the mechanisms of evolution than how it can fit in with their worldviews.

The exploration of links between the nature of science and understanding of evolution is a relatively new area of research (Hokayem & BouJaoude, 2008). Various authors (Rutledge & Warden, 2000; Scharmann & Harris, 1991; Sinatra et al., 2003; Smith & Scharmann, 1999; Southerland, 2000; Trani, 2004) have hypothesised a relationship between good understanding of the nature of science and greater likelihood to accept evolution. As yet, there is a small but growing amount of empirical evidence to support such claims (Lombrozo et al., 2008; Scharmann & Harris, 1991).

An early investigation was carried out by Johnson and Peeples (1987). Their findings from over eighteen hundred college biology students suggest that those with poorer levels of understanding of the nature of science are more likely to reject the theory. The research was set in a framework of what the authors asserted to be “correct” scientific understanding, yet there is no broad consensus about several of these matters. For example, the list included statements that would be disputed by some philosophers of science and religion, such as “scientists must limit their investigations to the natural world” (Section 2.2.3) and “the theory of evolution must deny the existence of a creator God” (Section 4.2). Although research by Scharmann and Harris (1991) showed increased appreciation of the applied nature of science and a rise in the acceptance of evolution after a three week course for teachers, findings were based on the same dubious instrument. Lombrozo et al. (2008) provide no evidence of the reliability or validity of the questionnaire that they used on their sample of US students.

5.2 Positioning of origin of life teaching within school

5.2.1 Boundaries between school subjects

The literature on the sociology of the curriculum provides an interesting context when examining how Science and RE departments interrelate in school. Particularly relevant is the work of Basil Bernstein who has written about the discontinuity between the culture of school knowledge and the culture of family, friends and communities (Bernstein, 1996).

Bernstein (1996) categorises the form and structure of the curriculum using two concepts: classification (a measure of the permeability of the boundaries between content) and framing (the degree of prescription or flexibility about what is taught).

Strong classification means that subjects and departments have well insulated contents with well-defined boundaries. There is a clear sense of membership and identity. The teacher has limited power over what knowledge is imparted because the boundaries cannot be breached.

Framing refers to the context in which knowledge is transmitted and received, and how this is regulated. The stronger the framing, the less the students' influence over what, when and how they receive knowledge as that power rests with the teacher (Bernstein, 1975).

According to Daniels (1995), strong classification and framing leads to separation of subjects, an emphasis on specialisation, and teachers who dominate at the expense of pupil autonomy. Weak classification and framing result in more symmetrical power relations between teachers and pupils: pupils are active and conditions suit inquiry-based learning perhaps with groups working at their own pace. In strong classification systems, there tends to be minimal inter- or intra-departmental communication because of the level of specialisation so there is little discussion or challenge (Bernstein, 1996). Weak classification on the other hand encourages a looser organisational structure and less clear identities, which could leave the system vulnerable to external influence unless staff form strong social networks.

Bernstein (1971) identifies two types of curricular structure: the collection curriculum (in which subjects have distinct boundaries and are well insulated from each other) and the integrated curriculum (where the subjects are linked and inter-dependent). Most state secondary schools in England show characteristics of the collection curriculum, with knowledge being clearly differentiated into different subject areas. The integrated curriculum typology is more common at the primary level, where teaching may follow themes that draw on inter-disciplinary knowledge.

Walford (2002) used Bernstein's framework in his analysis of the curriculum in private evangelical Christian and Muslim schools in the UK and the Netherlands. Although both sets of schools operated a collection curriculum with highly separate subjects, the Christian school had attempted to link subjects with biblical principles around God and creation. Walford reports that the resulting weak underpinning classification and strong framing would be matched at students' homes and lead to effective learning experiences – "some might say indoctrination" (p. 417). He stresses the need to take into account the worldviews and unstated assumptions in relation to which schools function.

5.2.2 Science as a cultural entity

Appropriate curricular models need to be adopted to provide culturally-sensitive learning experiences for students for whom Western science is a cultural entity representing just one alternative among a number of knowledge systems addressing the natural world. Three contrasting approaches were suggested in a special edition of Science Education

(Cobern & Loving, 2001; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001). These are expressed diagrammatically in Figure 5.1 and explained in more detail below.

Snively and Corsiglia (2001) argue for a cross-cultural pedagogy, where the conventional view of what counts as science would be broadened to include areas (such as spirituality) that are usually considered inappropriate. In this model, creationism and other religious beliefs about the origin of life and the universe would be incorporated alongside evolutionary theory. However, whilst being more all-embracing, this might blur the definition of what makes something scientific, weaken understanding of the nature of science, and risk being self-contradictory.

The multicultural pedagogy preferred by Stanley and Brickhouse (2001) treats Western science as one of several value-laden worldviews to be compared with a range of alternative and distinctive cultural systems. In a multicultural curriculum, evolution would be presented as the scientific viewpoint and different religious beliefs would constitute examples of alternative concepts. Although the sense of the nature of science is strengthened, there is a danger that the approach privileges science with the other worldviews relegated to implicitly inferior comparisons.

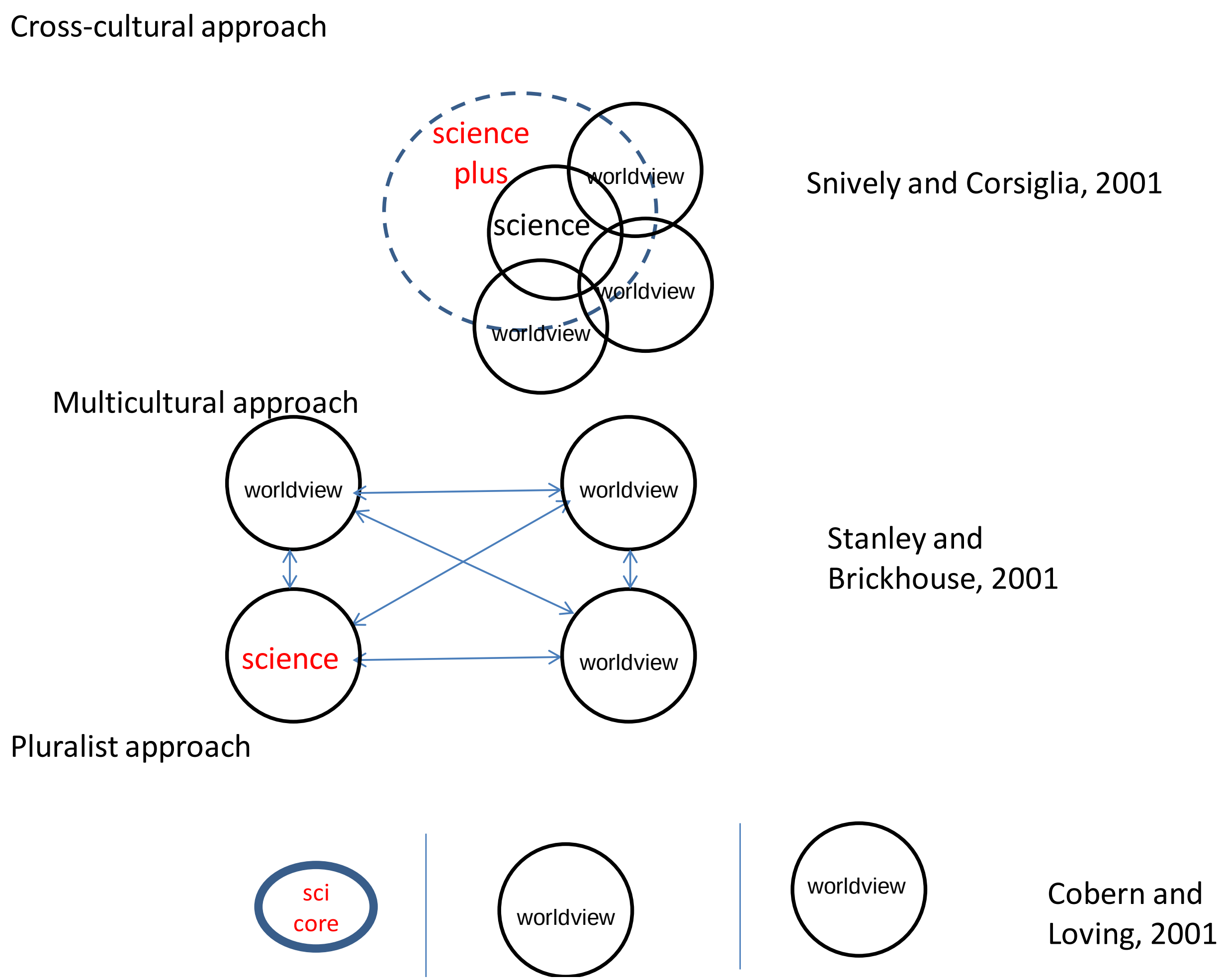
In contrast, the pluralist approach (Cobern & Loving, 2001) would restrict the discipline of school science to uncontested elements of Western science. Competing accounts from other worldviews would be covered separately elsewhere in the curriculum. This equates to the current position in most English schools, where the origin of life (and the universe) tend to be treated independently in Science and in RE classrooms. This reduces the danger that alternative worldviews are subsumed by Western science, but potentially removes Science teachers from discussions about how the nature of science fits in with alternative worldviews.

Waiti and Hipkins (2002) discuss using a pluralist teaching model to introduce Maori ways of knowing in New Zealand schools. They urge some degree of collaboration between departments to avoid a silo mentality. Their words can be applied equally to religious ways of knowing:

> While the use of very different ‘discursive spaces’ could help overcome the problem of Science teachers not feeling comfortable about their ability to discuss Maori worldviews, there is a danger that they could opt out of any NOS [nature of science] discussion if they are not part of the discussion of other world-views. Ideally, if two teachers are involved, both need to be present to hear and respond respectfully to the various parts of the debate. (p. 9)

Several studies have concluded that students should be provided with the opportunity to discuss their views of the interaction between science and religion especially in relation to evolution and creationism (Ingram & Nelson, 2006; Johnson & Peeples, 1987; Meadows et al., 2000; Woods & Scharmann, 2001). Scharmann (2005) recommends an approach to teaching evolution that stresses its practical role in science but also provides discussion space for students to explore their cultural and religious concerns. The three models outlined above would vary in how, and to what extent, this was achievable. It is most obviously a part of the multicultural approach but may need teasing out for the cross-cultural model. As already discussed, special efforts would be necessary to incorporate suitable opportunities within a pluralist curriculum.

Figure 5.1: Culturally-aware approaches to teaching Western science



5.2.3 Interaction of religious and science education

As was seen in Section 3.1, Science and RE – as well as evolution and creationism – are treated in a variety of ways across different countries. This diversity of approaches is reflected in the literature, often in a forceful manner.

Mahner and Bunge (1996b) equate teaching religion to teaching magic and pseudoscience, and are adamant that it should not be done. They claim that religious education should not feature within state education because it might interfere with attempts to instil a scientific way of thinking (Mahner & Bunge, 1996a). Based on an implicit and unsubstantiated assumption that science is a superior mode of knowing, they recommend that religion is studied from a principally scientific point of view – how it is explained in biological or psychological terms, for instance. Perhaps in a deliberate attempt to be provocative (being the lead article in this journal special issue on science, religion and education), they sometimes use intemperate language, referring to: “obscurantists, charlatans and crackpots such as, e.g., New Agers, astrologers, quack physicians...” (p. 118). Philosophy, they declare, is the only discipline where the religious worldview should be treated as an alternative to the scientific one.

Mahner and Bunge (1996a and b) are writing from a Canadian perspective and assume RE to be denominational and intent on indoctrination. They argue that it is inimical to nurturing a scientific mentality because it endorses faith without evidence or even despite the evidence, blurs myth and fiction with confirmed hypothesis, and selectively suppresses critical thinking. Several authors responding to their writing accuse them of operating from a materialistic position that is equally as closed-minded as the entrenched position they claim religious advocates adopt (Lacey, 1996; Settle, 1996; Woolnough, 1996). Citing the UK model of RE, Poole (1996) counters that the subject can actually broaden the mind. Woolnough, also writing from a UK angle, disputes the representation of RE as narrowly doctrinal. He supports the development of courses which will enable students to compare and contrast scientific and religious ways of thinking.

Beyond the justification of RE as a school subject there is the further issue of whether religious beliefs should be discussed in the science classroom. Aikenhead (2001) suggests that the degree of difference between a student’s own culture and the culture of school science, and the ability with which they cope with that difference, will determine how easily they can assimilate scientific knowledge. On this basis, it could be argued that ignoring relevant religious beliefs in science lessons might be detrimental to students as it closes a potential forum for exploration. Reiss (2009) urges teachers to recognise that a belief in creationism may be part of a student’s worldview rather than resulting from a lack of knowledge, and that if a creationist view is aired by a student it should not be disregarded. A worldview is very difficult to change (Gauld, 2005; Reiss, 2009) which is why many educationists argue that the aim should be to improve student understanding rather than alter their opinion.

5.3 The importance of cultural context in the teaching of evolution

Social constructivism, which came to prominence during the last quarter of the twentieth century, is now considered by many science educators to be the most influential learning theory in Western science education (Duit & Treagust, 1998; Labudde, 2008; Matthews, 1998). It stands in contrast to the transmission model of learning favoured by the behaviourists, in which students passively absorb new knowledge from the teacher. Instead, students are conceptualised as actively constructing their own learning through an interaction between what they already know, discussion with others, and new information. Constructivists stress the importance of establishing students' prior conceptions and working with them as appropriate – sometimes with the expectation that these existing conceptions will eventually be rejected (Bennett, 2005). Cobern (1995) takes this a stage further in what he terms the "cultural constructivist approach". Here, a person's cultural context, including religion where relevant, forms an additional layer of the model. Any concept that fails to fit within this framework will not be believable to the individual. Such a constraint could clearly be of crucial importance in the classroom when teaching evolutionary theory.

Numerous studies involving evolutionary theory lend weight to the idea that learning does not take place in a cultural vacuum and religious beliefs have been shown to hamper students' willingness to accept scientific evidence. Although the majority of these studies have been based in the US (Lawson & Worsnop, 1992; Sinclair & Baldwin, 1995; Woods & Scharmann, 2001), they have been supported by similar findings in other countries such as the Lebanon (Dagher & BouJaoude, 1997) and Scotland (Downie & Barron, 2000).

5.3.1 Conceptual change model

Conceptual change theory is set within the theoretical framework of social constructivism. The process of conceptual change involves taking a current belief or idea and fundamentally changing or even replacing it, as outlined in the seminal text by Posner, Strike, Hewson and Gertzog (1982). For a new concept to be accepted, the learner must firstly perceive a problem with the existing one and be looking for a replacement. In addition, the new one must be understandable, plausible and potentially useful.

Various teaching strategies have been employed to achieve conceptual change, but all appreciate the importance in this model of identifying and acknowledging students' prior conceptions and understanding before they can be built on or challenged (Scharmann, 2005; Smith, 2010). Fysh and Lucas (1998) recommend adopting an instructional approach using techniques such as small group discussions to air beliefs. Another commonly advocated approach is cognitive conflict, which anticipates that students recognise their preconceptions are incompatible with the new information being presented, and through a logical process will set aside their existing ideas for the new, more convincing ones (Limón, 2001). If these prior conceptions consist of religious beliefs, Demastes, Good and Peebles (1995) argue that they should be treated differently because they are not as susceptible to rational argument as other alternative conceptions might be.

There have been a number of educational interventions designed to achieve conceptual change to improve students' acceptance and understanding of evolution (Bishop & Anderson, 1990; Duveen & Solomon, 1994; Jensen & Finley, 1995; Matthews, 2001; Settlage, 1994; Zuzovsky, 1994). Many of these studies report that the interventions have improved students' understanding of evolutionary theory and the process of natural selection, but the evaluative approach has often lacked rigour. Almost all are based on small sample sizes and use a pre and post test measure designed with the content of the course in mind and lacking any form of comparative data. For example, after running a 4-week course that incorporated religious and indigenous creation stories as well as evolutionary theory, Matthews (2001) recorded a statistically significant shift towards more scientific conceptions among her 37 college students. Her claims to have evidenced an effective instructional approach are undermined by the lack of a control group, making it impossible to assess whether a different outcome would have been achieved without the creation stories.

Conceptual change theory is not without its detractors. Two related criticisms are of particular relevance to the teaching of evolution. Both focus on the treatment of beliefs. Firstly, there is a risk that an over-emphasis on the cognitive aspect of learning leads to marginalisation of the affective dimension, including the impact of students' beliefs (Sinatra et al., 2003). Perhaps an even more serious flaw in the context of evolution is that all beliefs not supported by conventional Western science, including religious ones, are dismissed as misconceptions that have to be discarded (Hokayem & BouJaoude, 2008).

Even in the literature, there is no unanimity about what constitutes a non-scientific or pseudoscientific belief. For instance, some authors refer to belief in the human soul as a concept that needs correcting (Eve & Dunn, 1990; Lawson & Worsnop, 1992), whereas others would see no conflict between such belief and scientific knowledge (Fysh & Lucas, 1998).

The implication that students' ideas are of no value whereas scientific knowledge represents a body of immutable truths runs through much of the conceptual change literature (eg Chinn & Brewer, 1993; Matthews, 2001).To remedy this, there have been moves to use the term "alternative conceptions" rather than "misconceptions" (Clement, 1993). Nevertheless, references to misconceptions still appear to dominate the literature (eg Hamza & Wickman, 2008). Educators working with indigenous cultures (for example Aikenhead, 1997) argue that it is imperative to broaden the definition of science to include alternative conceptions. The assumption of the superiority of Western science which is inherent in conceptual change instructional approaches may prove problematic and even alienating for those students who come from very different perspectives.

5.3.2 Cross-cultural border crossings

An alternative to conceptual change that is more sympathetic to the cultural background of the students focuses on facilitating border crossings from the students' everyday world into the school environment. It has been written about extensively in a number of papers (Aikenhead, 1996; Aikenhead, 2001; Aikenhead & Jegede, 1999; Donnelly, Kazempour, & Amirshokoohi, 2009; Jegede & Aikenhead, 1999; Taconis & Kessels, 2009). Whereas the conceptual change model is based on aligning student beliefs, understandings and worldviews with science, the border crossings framework explores how to manage any incompatibilities whilst allowing students to maintain respect for their home culture. Enabling a crossing between two cultures, those of the student's home environment and of school science, becomes the focus and the challenge.

Phelan, Davidson, and Cao (1991) categorise students according to how well their operating environments (school, family, peers) fit together and how well they negotiate the borders between these different worlds. Using this framework, Costa (1995) developed a typology of students based on how easily they succeed at science, which reflects the degree of difference between the home and school cultures, and how well students are able to cope with that difference. She proposes five categories as follows:

- "Potential scientists" experience a seamless transition into school science.
- "Other smart kids" are intelligent and their home and school worlds are compatible, but they do not value science as a subject.
- "I don't know" students find inconsistencies between the home and school environments, although they are not negative towards the latter and they perform reasonably well.

- "Outsiders" experience discord between home and school cultures. As a result, they are alienated from both school and science and are highly unlikely to successfully participate in school science.
- "Inside outsiders" find their everyday world irreconcilable with school, although not necessarily with science. This makes it very difficult for them to get involved in school science.

Costa's schema is shown in Table 5.1 along with a sixth category suggested by Aikenhead (2001). He identifies an additional group of students who, although very interested in school science, find the border crossing from their home world challenging, primarily for cognitive reasons. He incorporates them into Costa's schema by proposing the grouping "'I want to know'" students.

This typology is useful in illustrating the factors that may be influencing how individual students respond to science at school. However, the basis for the categorisation is far from robust. The main framework was developed from interviews with only 43 high school science students in California (Costa, 1995). Aikenhead (2001) proposed his additional sixth category based on just two individuals from his own studies and an analysis of interview data originating from other researchers.

Table 5.1: Student typologies (based on Costa, 1995)

Typology	Ease of transitions	Home vs school culture	Home vs science culture	Performance in science
Potential scientists	smooth	congruent	congruent	can do and want to do science
Other smart kids	manageable	congruent	inconsistent	can do science, choose not to
"I don't know" students	hazardous	inconsistent	inconsistent	neutral about science
"I want to know" students[1]	adventurous	inconsistent	inconsistent	keen; acquire limited but effective understanding
Inside outsiders	frustratingly difficult	irreconcilable	potentially compatible	reasonable understanding but alienated from school
Outsiders	virtually impossible	discordant	discordant	poor performers, alienated from school

[1]Aikenhead (2001)

The role of the teacher is vital in providing a successful cultural approach to science instruction (Jegede & Aikenhead, 1999). The aim is for students to learn about the culture of science but not feel compelled to adopt it. For maximum effectiveness, the degree and type of input must be tailored to the needs of the student. Jegede and Aikenhead use a travel analogy to suggest appropriate teacher roles for each of the student groups in Costa's typology. At one extreme, when dealing with students who require a lot of support, such as the "I don't know" category, teachers should fulfil the role of a tour guide who explains how science operates and points out main areas of interest. Where a lighter touch is sufficient (for example, with "Other smart kids"), teachers would act as travel agents, operating a looser support framework which enables students to explore for themselves.

One of four different processes results from the interaction between ease of transition, student typology and teacher action (Jegede & Aikenhead, 1999). These are as follows:

- Enculturation is likely when students have worldviews that are already in harmony with science (as with "Potential scientists"). Trouble-free border crossings are achievable because the ideas from the two cultures are mutually supportive. When students experience greater discord between the two worlds, they have recourse to alternative models of learning.
- In acculturation, the student consciously selects which aspects of science they are willing to accept as part of their worldview. They choose to adopt elements that they find attractive or useful. Insofar as it involves amendment of their existing framework, this is similar to the conceptual change model, but crucially it is the student who decides what to incorporate.
- Anthropological learning happens when the student accepts scientific ideas alongside their cultural ones so concepts are multiplied rather than replaced. Jegede and Aikenhead describe this as a sophisticated position that requires the student to switch between explanations when moving from one context to another.
- Jegede and Aikenhead argue that the fourth process, assimilation, is often found in science but should be avoided. They characterise it as forcing students to choose between their existing cultural concepts and scientific ones. As a result, they may become alienated either from their home culture (with negative social implications) or from science. The latter can mean students fail to engage with scientific knowledge, reserving it exclusively for examination situations. They might adopt specific tactics that are designed to obtain a pass in science without genuinely involving themselves with the subject content (Aikenhead & Jegede, 1999). A student explained to Larson (1995) the superficial devices she employed to ostensibly "succeed" in science (eg to

> pass exams or complete work quickly, creating time for "off task" activities). He dubbed them "Fatima's rules". They included focusing on key terms, charts and review questions in textbooks and selective memorisation for exams. Aikenhead and Jegede suggest that alienated students may use these along with additional resistance tactics, such as remaining silent in class, to avoid being assimilated by school science.

Jegede and Aikenhead (1999) propose that teachers should aim to achieve different outcomes depending on the student typology they are confronted with. Acculturation might be applicable to Costa's "Outsiders" and "I don't know" students, whereas anthropological learning could prove more appropriate for "Other smart kids".

Jegede (Aikenhead & Jegede, 1999) puts forward the concept of collateral learning to explain how students whose everyday culture is in conflict with science deal with the conflict cognitively. He suggests that two views can be held simultaneously in the long-term memory. A spectrum of collateral learning is proposed. At one end sits secured collateral learning, with discrepancies between the schemata explicitly acknowledged and resolved. At the other end, parallel collateral learning, students keep the conflicting schemata completely separate so they operate independently. This has been labelled cognitive apartheid by Cobern (1996) to describe the strategy of students who keep scientific knowledge secreted away for special occasions such as exams, after which it is likely to atrophy.

Aikenhead (2001) concludes that learning science is cross-cultural for most students (regardless of indigenous culture or religion) and they need help to negotiate the border crossings. Nevertheless, much of the work on cross-cultural border crossings has focused on the curricular and pedagogical implications for students from indigenous and/or non-Western communities, such as First Nations in Canada (Aikenhead, 1997), Maoris in New Zealand (Waiti & Hipkins, 2002) and contemporary traditional Japanese (Aikenhead & Ogawa, 2007).

Many of the implications in the literature seem to be applicable to religious as well as indigenous communities because the challenge is to harmonise potentially conflicting knowledge systems – what the student brings from their home context with what they are taught in school science. Aikenhead and Jegede (1999), for instance, have taken the case studies of three religious students at a Christian boarding school (originally reported by Roth & Alexander, 1997) and interpreted them in the light of collateral learning theory. These three were focused on in the original study because they represented the range of viewpoints in the class. One, Todd, experienced the religious and scientific worlds as congruent so his transitions were smooth and he achieved secured collateral learning with minimal need for teacher support. Ian provided an example of parallel collateral learning: he found the worlds incompatible and coped by keeping them separate, deciding which knowledge to prioritise on a case by case basis. For Brent, the worlds were at odds to a degree he found insurmountable. He was alienated by what he saw as attempts to assimilate him, resisted transition and consequently no collateral learning occurred.

The literature underlines the importance of the cultural and religious context in mediating a student's interaction with school science. It also suggests that assessing a student's engagement with science simply by how they present themselves and their work in class may not give an accurate picture: they may just be adopting a version of Fatima's rules.

5.4 Summary

This chapter has demonstrated how the theory of evolution has an important role within a curriculum designed to achieve scientific literacy. As well as being a fundamentally important overarching concept, it also illustrates a controversial issue and different elements of the nature of science.

The evidence about whether understanding of evolution is correlated with its acceptance is mixed and inconclusive. There is stronger evidence that poor understanding of nature of science is linked to greater likelihood to reject evolutionary theory, and that those with religious beliefs have higher rejection rates than those without.

There is a lack of clarity about what educational approach should be favoured when the origin of life is tackled in schools. Some insist that religious explanations have no place in the science classroom. Others contend that it is beneficial for students to explicitly compare and contrast the different viewpoints. The considerable amount of literature supporting these two perspectives share two limitations: the arguments tend to be based on opinion rather than empirical evidence, and they almost all have a Western, Christian bias.

The chapter has discussed how conceptual change theory, popular in science education, provides a limited and possibly dangerous model for teaching evolution. It risks alienating students by inadequately recognising or respecting their religious views. The alternative model of cross-cultural border crossings offers a less confrontational approach. It acknowledges students' fears that getting involved with science might mean having religious beliefs subverted and it suggests ways of managing this. This leads to formulation of two key research questions:

> *What are students' opinions about the scientific and religious explanations of the origin of life?*

Are there differences between students' own religious or cultural beliefs about the origin of life and what they are taught in school? If so, how do they accommodate these?

Edis (2009) describes evolution as "the most prominent flashpoint between modern science and conservative Abrahamic religions" (p. 886). This chapter has shown that there is no consensus about how this flashpoint should be managed in the science classroom.

6. Research design and methodology

This chapter examines the rationale behind the approaches used for data collection and analysis. It goes on to outline the construction of the sampling frame and the research instruments, exploring the methodological issues raised and how they were tackled. Details of how the pilot fed into the main study are provided and the analytical method is described. The final sections consider my own role as researcher and the ethical aspects of the research.

6.1 Research approach

After considering what would be most appropriate and effective way of tackling my research questions, I decided to use both qualitative and quantitative methods. I chose grounded theory as the most suitable foundation for the analytical process. However, adopting grounded theory has implications for much more than the analysis: it also affects the set-up and running of a study. For this reason, the principles of both mixed methods and grounded theory are covered in this opening section.

This pragmatic approach to selecting research methods, where social enquiry is prioritised over purity in terms of methods, has been contrasted with the paradigm-oriented position. In the latter, the researcher is more concerned with ideas and their origins, and the ideals behind the research. Tashakkori and Teddlie (2003) describe the pragmatic philosophy as:

> a deconstructive paradigm that ... focuses ... on 'what works' as the truth regarding the research questions under investigation. Pragmatism rejects the either/or choices associated with the paradigm wars, advocates for the use of mixed methods in research, and acknowledges that the values of the researcher play a large role in interpretation of results. (p. 713)

6.1.1 Mixed methods approach

Using mixed methods involves drawing on both quantitative and qualitative research traditions. It is a relatively recent development in academic studies and remains contentious in those quarters where the divide between the two is still regarded as unbridgeable (Brannen, 2005; Hantrais, 2005). My position is that there is a powerful synergetic potential in bringing the two approaches together where appropriate. This section contextualises the use of mixed methods in general terms and for this study specifically.

Quantitative methods have been linked with a natural science (positivist) approach and are characteristically used to measure "how much" or "how many", or to establish correlations or causal relationships. The aim of quantitative studies is often to test or confirm a hypothesis or theory using deductive reasoning. Data (usually numerical) are collected in a systematic way which enables replication, and the research is designed to be nomothetic, ie yielding findings which can be generalised to the wider population. It is claimed that the research is less subject to influence from the researcher, who adopts the perspective of an outsider.

In contrast, qualitative methods are more associated with a social science (interpretivist) approach. They look at questions of “how” and “why” by investigating relationships between events and activities. The outcome is idiographic, ie rich data relating to a particular time and place. Using an inductive and exploratory process which remains faithful to the original material, theory emerges from the data. The process is flexible and heavily influenced by the researcher at all stages, from design and delivery to analysis and interpretation, making it responsive to emergent findings and participants’ viewpoints.

The quantitative approach has been criticised for producing unfounded generalisations which are not applicable to individual instances. The research instrument is pre-determined and consequently there is less scope for data to reveal surprises. Another problem is that the methods can serve to distance the data from the participants – stories and meanings are hidden and the focus is often on theories that have no relevance to the community being researched. Qualitative research, on the other hand, cannot usually be generalised or replicated, leading to claims that it is too subjective and over-reliant on the researcher, who can privilege one interpretation over another. Adjectives such as “soft” and even “an assault on truth” have been applied to the data (Fairbrother, 2007). The attraction of mixed methods is that it might enable a blending of strengths and mitigation of the weaknesses.

Historically there was resistance to the idea that quantitative and qualitative research methods could be integrated. Some authors argued that the approaches represented two incommensurable paradigms with different philosophical and methodological roots (eg Lincoln & Guba, 1985; Sale, Lohfield, & Brazil, 2002; Smith & Heshusius, 1986). However, such a rigid stance has become increasingly unpopular. Mingers (2003) calls the dichotomy ‘crude’ and Jones (2004) maintains that imposing a divide between the techniques obscures basic similarities. To Yin (1989) the distinction lies more in the data than the methodology – for instance, some survey questions yield qualitative evidence.

More recently there has been a move in social sciences away from the view that the two strategies cannot be mixed and towards a recognition that they might be fruitfully combined. ‘Mixed methods’ has become a more acceptable term. The alleged incompatibility is now less hotly or regularly debated and whole chapters (Bryman, 2008;

Creswell, 2009; Denscombe, 2007) or entire books (Gorard & Taylor, 2004; Greene, 2007; Teddlie & Tashakkori, 2009) are devoted to the mixed methods approach. Bryman ascribes its growing acceptance and use to an increased recognition of research methods simply as ways of collecting or analysing data, not bound by epistemological or ontological ties.

The focus of criticism of mixed methods has shifted instead to examining whether genuine integration has been achieved. Many critics stress that simply using different methods does not justify the term ‘mixed’. For Bryman (2008), it is the findings (as well as the methods) that must be integrated. For Flick (2009), a satisfactory mixed methods strategy uses the two approaches in an even-handed and inter-related fashion. Less dogmatically, Creswell, Plano Clark, Gutmann, and Hanson (2003) define mixed methods as:

> the collection or analysis of both quantitative and qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve integration of the data *at one or more stages* in the process of research” (p. 212) [my italics]

It is important that the two methodologies interact and have something to offer in combination that could not be achieved by using them separately, and they are not simply employed in parallel to pay lip service to the growing fashionablity of the approach. However, the insistence by Flick (2009) that there should be no “subordination” of one approach by the other seems too rigid, because one or other might well be prioritised in the mix to suit the nature of the inquiry. Bryman (2008) and Ivankova, Creswell, and Stick (2006) both give descriptions of many possible models.

Tashakkori and Teddlie (2003) identify three advantages of mixed methods: they can answer research questions other approaches cannot; they provide stronger inferences; and they allow a greater diversity of views to emerge. Further illustration of this flexibility and adaptability comes from Greene, Caracellli, and Graham (1989), who list five possible purposes of a mixed research design:

- triangulation: cross-checking the findings achieved by different methods to ensure that they are not just an artefact of the means of data collection, inquirer bias or the context of the inquiry
- complementarity: results from one method can clarify or elaborate on those obtained from another, improving interpretability
- development: results from one method can be used to develop the other, eg feeding into sampling decisions and question design

- initiation: the different methods can throw up paradox and contradiction and increase the breadth and depth of results and interpretations by analysing them from different perspectives
- expansion: can extend the scope of the inquiry by broadening its range.

Achieving complementarity, alongside some methodological triangulation, was of particular relevance in designing this study. Surveys were used when a measure of breadth and frequency of behaviour, experiences or opinions was necessary. To uncover deeper, more subjective insights into attitudes, beliefs and motivations, semi-structured interviews and focus groups were used. Techniques (which are described in more detail in Section 6.3) were matched to research questions as follows:

What are Science and RE teachers' opinions about teaching scientific and religious explanations of the origin of life?

- teacher survey and teacher interviews: survey to establish broad picture of teachers' standpoint on whether the topic is controversial and whether religious explanations should be covered in science lessons. Interviews to examine in more detail how teachers tackle the topic and in what way it has been controversial, ie providing richer data from a more limited sample.

What are students' opinions about the scientific and religious explanations of the origin of life?

- student survey and student pairs and small focus groups: questionnaire to seek students' views about how life on earth originated and the qualitative component to explore whether they consider it a controversial topic, ie providing information on a different aspect of the research question.

What are the differences, if any, between how the origin of life is dealt with in Science and RE classrooms?

- teacher survey and interviews; student pairs and small focus groups; lesson observations: teacher interviews provide more detail behind survey responses about what is covered in lessons, teacher confidence in covering explanations outside their specialism, and departmental collaboration. Student element provides an additional perspective on what is taught, and how. Lesson observations give direct access to classroom proceedings.

Are there differences between students' own religious or cultural beliefs about the origin of life and what they are taught in school? If so, how do they accommodate these?

- teacher survey and interviews; student survey, pairs and small focus groups: teachers' survey and interviews to explore their perception of how the topic is experienced by students. Student survey to provide insight into their viewpoints on the origin of life and what has influenced this. Qualitative aspect to provide more information about whether this produces conflict and, if so, how it is managed. Findings from all approaches can be triangulated.

6.1.2 Choosing grounded theory

A key early decision was whether to use a primarily inductive or deductive approach. In the former, a classification system develops from the data being examined, with the ultimate aim of generating theory ('bottom up'). In contrast, the latter begins with a pre-defined structure which is imposed on the data and aims to confirm, reject or expand on an existing theory ('top down').

In the social sciences, one of the most commonly accepted and widely cited ways of approaching qualitative research has, for many years, been grounded theory (Denzin as cited in Patton, 2002; Thomas & James, 2006). Its initial incarnation was described in the classic 1967 text by Glaser and Strauss, although the two originators subsequently parted company in terms of the detail (Glaser, 1992). The authors stressed that they were introducing system and rigour into the analysis process, without excluding creativity.

As its popularity increased, so did the variety of ways in which it is implemented (Charmaz, 2003; Corbin & Strauss, 2008). The common link across all these interpretations of grounded theory is that it privileges the data rather than prior knowledge and conceptions: emerging theoretical constructs are grounded firmly in the data gathered. This should make it understandable and of practical value to participants.

The emphases are on the interaction between the researcher and the data, and on a combination of systematic rigour and creativity (Strauss & Corbin, 1998). As theory emerges, it is constantly checked against the data for fit and consistency. Analysis takes place throughout the fieldwork stage, enabling it to influence data collection if unforeseen, potentially fruitful themes emerge. In this way, grounded theory can have significant implications for methodology and the development of research instruments.

The deductive approach stands in contrast to this because categories are devised before undertaking analysis by referring to existing literature, theoretical frameworks and the actual questions posed to participants as a basis. These methods, such as the one outlined by Miles and Huberman (1994), have the advantage that they explicitly recognise the pre-existing knowledge of the researcher, and produce a framework which even in its infancy fits with the research questions. A subsequent stage involves analysing the data inductively for themes arising from the research participants that were not anticipated in the *a priori* framework.

Some would argue that the main difference between the two approaches is simply a question of the order of operations. As Gomm (2008) points out, at some stage structure has to be imposed on categories which are grounded in the data, whilst analysts using pre-defined systems must make time to examine the data for unanticipated themes (Miles & Huberman, 1994).

It was clear that grounded theory's emphasis on allowing themes to arise from the data, rather than be dictated by pre-existing frameworks and conceptions, was more in keeping with one of the key motivations of the study - to provide a perspective on the topic which gave a voice to the views of students and teachers.

'Grounded theory' can be a loosely-used term. Authors have accused researchers of using it as a "rhetorical sleight of hand" (Suddaby, 2006, p. 633) or "a kind of whitewash" (Scott & Morrison, 2005, p.121) to add credence to their studies without revealing the detail of their processes. The proliferation of versions (Charmaz, 2003) can also lead to disagreements about what actually constitutes grounded theory, and proponents might also modify their opinions over time. For example, when Corbin explains how the new edition of *Basics of qualitative research* (Corbin & Strauss, 2008) differs from previous ones, she acknowledges that the book is "more open, analytically, reflecting changes that have occurred in myself" (p. x). With the lack of one agreed model of grounded theory, it becomes important that the methods followed are clear and transparent. In this particular case, the study aimed to incorporate the following elements:

- Being an iterative process: data collection continued alongside early analysis, allowing adjustments to the questions asked and, to some degree, to recruitment of the sample (theoretical sampling) as concepts evolved.
- Using the constant comparative method: statements were compared within then between interviews for similarities and differences; categories were compared to allow elaboration and differentiation, and to develop patterns; and finally the developing hypothesis was checked against the data.
- Developing codes sequentially: concepts evolving from descriptive to interpretive and becoming increasingly abstract.

- Achieving theoretical saturation in coding: the categories matched the data sufficiently well that the collection of further data would be superfluous.
- Writing memos: aides-memoires and reflective documents to keep track of analytical decisions, emerging patterns, ideas and thought processes as the analysis progressed.

This accords well with the characteristics that Corbin and Strauss (2008) identify as consistent across the different variants of grounded theory, namely: the use of constant comparison; the use and development of concepts; theoretical sampling; and saturation. The use of theoretical sampling (doing more data collection to fill gaps that emerge in the analysis) was slightly constrained by time and logistical considerations. Moreover, a fairly well-defined scheme of sampling and outline research instruments was needed from the start to get approval from the University of Southampton School of Education research ethics committee. As a result, theoretical saturation (reached when further sampling fails to produce any new categories) was not fully achieved although some sampling flexibility was possible informed primarily by the pilot study (Section 6.5). As Corbin and Strauss acknowledge, "with all research there is the 'ideal way' of doing things and there is the 'practical way'" (p. 153).

However, some of the assumptions behind grounded theory are questionable. In its earlier forms, grounded theory maintains that the researcher can put aside her or his preconceptions and approach the data in a completely open-minded way (Glaser & Strauss, 1967). It could be argued that this is a rather naive position because the very process by which one has already arrived at the data – from deciding on research questions to selecting the sample and designing interview guides – is heavily based on presuppositions. Because I had reviewed a considerable body of literature before embarking on the research, I could not enter the data collection or analysis stage completely free of context. More recently, many grounded theorists freely acknowledge the researcher's epistemological baggage and stress that – handled correctly - it should open up, not hold back, their work (Charmaz, 2003). Each researcher enters a project value-laden and theory-laden, and this prior input cannot be magically set aside. Instead, it should be reflected on as part of the research process and explicitly acknowledged in the write up.

6.2 Sample design

The grounded theory principles underlying the research affected the sampling strategy. Although grounded theory is often presented primarily as an approach to data handling (Heath & Cowley, 2004; Miles & Huberman, 1994; Turner, 1981), its adoption has implications for all stages of a study, including sampling and the design of the research instruments. One element of grounded theory is the use of theoretical sampling, which means that the sources of data collection are guided by the concepts and themes arising from early sampling and analysis. Research instruments are subject to alteration for similar reasons. The cyclical nature of the interaction between data collection and analysis allows modifications to be made to sampling and instruments to reflect issues that are emerging from the data.

Sampling was confined to the state school system, which the vast majority of children in England are part of (nine out of ten according to government figures[2]). Inclusion of the private sector would have introduced more variables: for example they do not have to follow the National Curriculum.

The focus of the research was the experiences of 14-16 year olds in Key Stage 4, ie Years 10 and 11, leading up to GCSE. At this age, students are approaching the end of their compulsory schooling but are still legally obliged to follow both Science and RE. Fieldwork in the case schools was timed so that, according to their teachers, the students had covered explanations of the origin of life in both subjects. For many, it would be the last time they formally studied this topic, but it is also an age where they are reasonably ‘mature’ in their thinking (Mann, Harmoni, & Power, 1989). In practice, one of the case schools did not offer RE as conventionally understood (although the lessons will be referred to as such in this document to preserve anonymity) and only had students at the very end of Year 9 available at the time of the research. However, because the school started Key Stage 4 a year earlier than most, they had already covered the big bang and evolution in their science lessons.

The fieldwork approach is illustrated in Figure 6.1. A postal survey of Science and RE teachers was piloted locally and undertaken nationally. It focused on teachers’ behaviour, experiences and attitudes around the teaching of the origin of life. A student questionnaire was piloted among students at a sixth form college who represented a range of religious and cultural backgrounds. The findings from these pilots steered me towards the criteria for determining profiles of case schools, which were chosen to represent diverse, rather than representative, contexts:

> School A: a faith school which might encompass some faith members that do not accept the theory of evolution (eg a Christian state school)

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[2] http://schoolsfinder.direct.gov.uk/

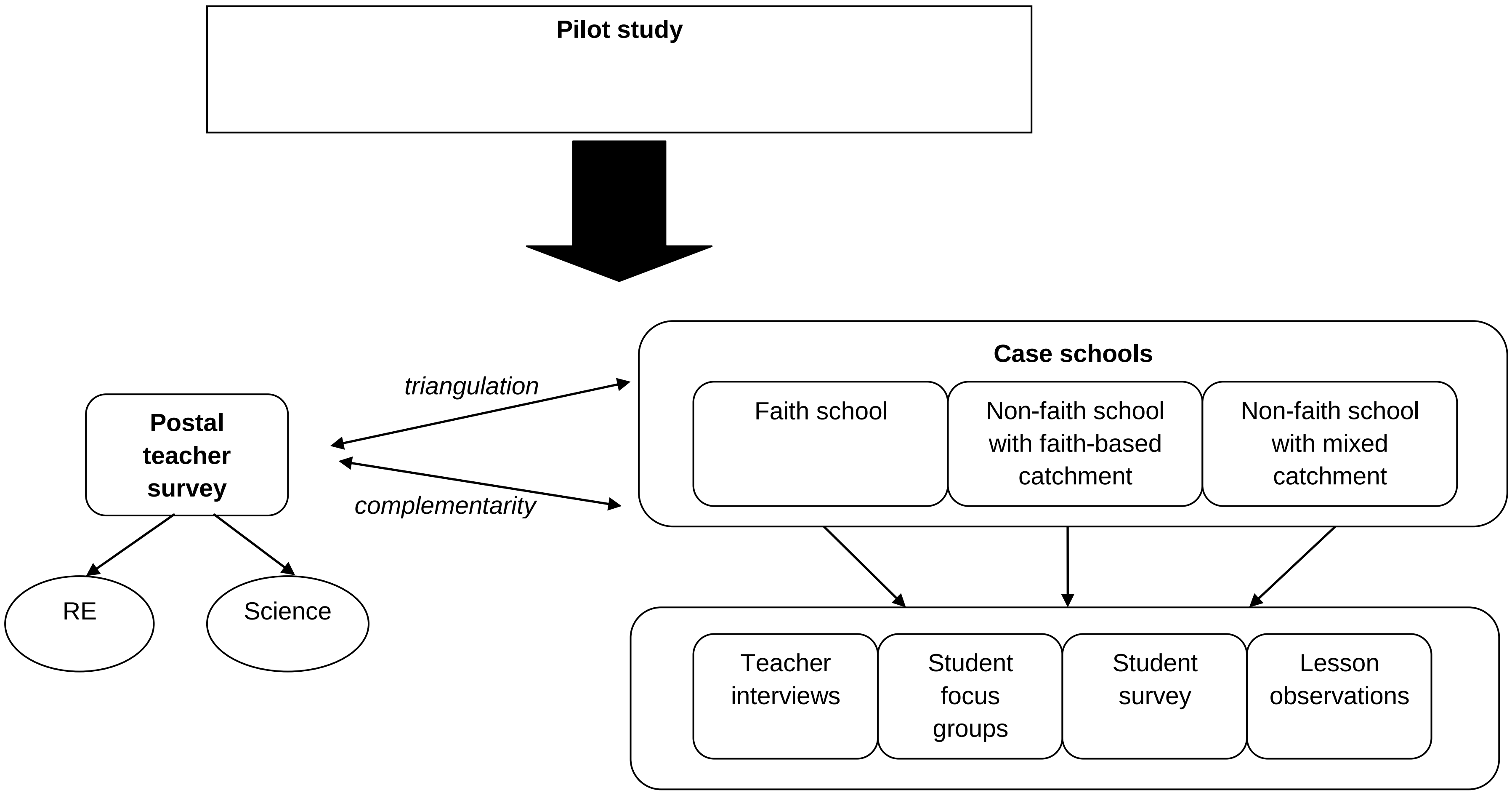
School B: a non-faith school situated in a community such that the theory of evolution might conflict with the faith of the majority of students (eg with a catchment of mainly Muslim families)

School C: a non-faith school where the students are not drawn from any particular faith background

This element of the study examined teacher and student attitudes, opinions and experiences in more detail. It consisted of student surveys, student focus groups, teacher interviews and lesson observations.

The sequencing of the fieldwork is detailed in Table 6.8 towards the end of the chapter. The content of the questionnaires was fixed, but the other elements were open to adaptation as the data collection and analysis progressed, if this seemed necessary.

Figure 6.1: Intended sample design



6.3 Data collection methods

This section outlines the different forms of data collection that were employed to tackle each research question. Consideration is given to the reasons for using each approach, and how any limitations were dealt with.

6.3.1 Using questionnaires

Surveys, in combination with other methods, were used to address all of the research questions. It was intended that a survey among teachers would establish the range of opinions about teaching the various explanations of the origin of life, the diversity and prevalence of those opinions, and any similarities or differences between Science and RE teachers. Comparing responses from teachers in the two disciplines would also shed light on how the origin of life was dealt with in the different subjects. A student survey was conducted primarily to discover what views students held about how life on earth had been formed and to examine whether these were religious or scientific in nature.

Self-administered questionnaires were chosen for a number of reasons. They allowed me to get responses from a large number of people without being too costly and time-consuming. In the case of the teachers, using a postal (and subsequently an online) survey meant a geographically widespread sample could be contacted cost effectively. In the case of the students, where completion under some form of supervision was desirable to increase the response rate, teachers could easily introduce it to their class if I could not be there in person. A potential advantage for respondents was that, if they were concerned about privacy, they did not have to provide their name or school details so perceived anonymity should have been high. Although in some cases I was present to hand out the questionnaire, answering to please the researcher is much less of an issue than for interviews.

On the negative side, there was a danger that respondents might miss out questions inadvertently or fail to return the form at all. To maximise response rates and minimise missing data, the questionnaire was kept short and simple, with no complex response-dependent routing.

A key reason for using the questionnaire format was that its structured nature allows data to be gathered in a standardised way enabling direct comparison between subgroups (eg Science and RE teachers; students from different faith positions). However, the pre-determination of responses to closed questions forces fixed categories (which may not always be the most appropriate) on respondents. Strategies such as judicious use of open-ended questions and the inclusion of an ‘other, write in’ option in closed questions were used to offset this problem as far as possible.

Open-ended questions have their own drawbacks. In analysis terms, it can be difficult to judge intensity of feeling from written responses, so it is important where appropriate to use scaling, such as Likert scales or horizontal rating scales (de Vaus, 2002). Also, they tend to favour the more literate and expressive respondents (whose responses then get more weight in the analysis) or those with more time, whereas others give brief or non-existent answers. Because there is no intermediary to explain or guide, the wording might be misunderstood leading to irrelevant (or even misleading) answers. Again, ensuring that the questions were concise and easily understood, and mixing closed and open formats, helped mitigate these problems.

6.3.2 Using depth interviews

Individual, in-depth interviews were adopted to explore a number of the research questions with teachers, specifically to look at: their opinions about teaching scientific and religious explanations of the origin of life; whether there are differences between how it is dealt with in Science and RE classrooms; and teachers' experience and perceptions of discontinuities between students' religious or cultural beliefs about the origin of life and what they are taught in school.

A major benefit of using interviews is that the researcher interacts directly with the participant. There is much more scope for follow-up to obtain further detail or clarification compared with a self-completion questionnaire, and greater flexibility of questioning means that unanticipated themes can be explored if appropriate. It also facilitates the establishment of good rapport. Another advantage over questionnaires is that participants who are less literate are not put at a disadvantage, although others will be less at ease expressing themselves verbally than in writing.

The issue of interviewer neutrality is even more important than in quantitative methods because the potential for bias is not just limited to question wording: the research instrument is effectively the researcher rather than the questionnaire. So, although interviews enable the collection of in-depth information and have good interpretive validity (as both interviewer and participant can check for meaning and understanding), they are also susceptible to investigator effects. According to Gomm (2008) these effects are magnified when the topic is a sensitive one. Reactivity (the process of collection affecting the data collected) can also be an issue – for instance, participants supplying the responses they think are either more desirable or socially acceptable to the researcher. Related to this is the risk of hot-housing a topic so that it acquires for the participant a saliency that does not accurately reflect its importance in their everyday life. It is important to give research participants 'permission' to acknowledge that, for instance, the research topic is not one that would usually concern them.

Individual interviews were chosen over teacher focus groups for several reasons. My previous experience of research with teachers suggested that they tend to be keen to contribute to a discussion, and the group context was unlikely to give them full opportunity to do so without problems of talking over each other and going off-task. There was also a chance that some teachers might defer to those with stronger views or greater perceived knowledge of the topic. Interviews would allow individual responses to be tracked and explored thoroughly. More pragmatically, it is easier to arrange time with one busy professional than a whole group together and if absolutely necessary the exchange could take place over the telephone. Also, the unit of analysis was not always large enough to support a focus group (eg RE teachers within one school). Using this technique did however mean that breadth of coverage was sacrificed for depth of individual response.

6.3.3 Using pairs, triads and focus groups

A combination of pairs, triads and small focus groups was used to explore aspects of three of the research questions among students: to establish their standpoint on the scientific and religious explanations of the origin of life; to investigate any differences they perceived between its coverage in Science and RE classrooms; and to examine how they accommodate any differences between their own religious or cultural beliefs about the origin of life and what they are taught in school. This methodology was used to enable individual depth of focus as well as providing the opportunity to react to each others' contributions. Students were taken out of Science or RE lessons, so any logistical difficulties and educational disruption were minimised.

Lewis (2003) recommends keeping the numbers involved at any one time lower than the typical 6-8 focus group members when younger people and/or potentially intimidating issues are involved:

> Smaller groups, pairs or triads might provide a good balance between the group and the individual context ... They [...] allow participants to reflect on, and draw comparisons with, what they hear from others, but they are a more private research forum in which each participant has more time to talk. (p. 59).

From my own experience, I anticipated that individuals taking part alongside their peers would make the atmosphere feel more supportive and help the students relax. In the first school, the students participated in pairs, but this did not always provide the necessary interaction to stimulate a fruitful discussion. Most subsequent sessions therefore comprised three or four students.

Focus groups share many characteristics with in-depth interviews but have additional benefits and drawbacks that accrue from being a technique that allows, and indeed encourages, interaction between participants. As with interviews, the researcher can probe for details or clarification and has the flexibility to incorporate unexpected issues. Because of the numbers involved, the direction of a focus group can be less researcher-dominated than a one-to-one interview. As a consequence, investigator effects (although still present) may be diluted, but the same danger of distortion through reactivity and hot-housing applies.

Confidentiality is limited in the focus group situation, because group members hear each other's contributions. On the positive side, this can stimulate discussion and promote cross-fertilisation of ideas. It can also act as a check on the truth of participants' contributions (respondent triangulation), with members of the group being unlikely to risk making remarks that their colleagues know are false (Denscombe, 1995). Equally, however, it may lead to peer contamination - inhibiting honest feedback, producing comments made 'for public consumption' and creating a pressure towards conformity (Gomm, 2008).

Although being part of a group may mean members are exposed to a multiplicity of standpoints, and that the researcher might observe the process of shifting views, there may also be a move towards a false consensus (eg because one participant is dominant, or to 'please' the researcher). The group situation may also make it easier for members of a group to take a distant rather than a personal stance on an issue (Finch & Lewis, 2003). It is sometimes difficult to distinguish an individual from a group view because not all participants express their views clearly or frankly, and identifying each speaker when transcribing an audio recording can be problematic.

Group dynamics mean that the researcher has less control over the process than in an individual interview, and the discussion may get diverted more easily into irrelevancies. As with the depth interviews, I had a list of topics to cover rather than a rigid schedule, but this helped ensure that all key aspects were covered.

From the point of view of participants, verbal methods are better than written ones for enabling use of everyday language and getting feedback from the less literate. However, they discriminate against the very shy or quiet student and it is challenging to encourage contributions from all participants (especially adolescents) without causing embarrassment.

Table 6.1 summarises the main advantages and disadvantages of the different techniques.

Table 6.1: Summary of the advantages and disadvantages of different data collection methods

	Self-completion questionnaires	Depth interviews	Focus groups
Advantages	easier access to large sample geographically widespread cost effective allows respondent anonymity enables sub-group comparison	can follow up unanticipated themes can probe for detail can reduce misunderstandings easier to build rapport in one-to-one session	can follow up unanticipated themes can probe for detail can reduce misunderstandings stimulates interaction/cross-fertilisation of ideas supportive environment dilutes investigator effects provides truth check (respondent triangulation)
Disadvantages	must keep questionnaire short danger of non-response (especially postal) closed questions restrict answers open questions favour more literate respondents/those with English as first language questions can be misinterpreted intensity of feeling not always clear	flexibility lessens comparability between interviews increases investigator effects responding to please researcher danger of hothousing	flexibility lessens comparability between sessions responding to please researcher danger of hothousing peer contamination risk of false consensus can facilitate impersonal rather than individual stance can inhibit quiet/shy participants

6.3.4 Using observations

I planned to observe some Science and RE lessons that dealt with the origin of life to help establish whether the topic was tackled differently in the two subject areas. I chose observation as it would provide me with direct experience of the teaching process which otherwise I would be aware of only through teacher and student reports.

Observation is good for description and enables access to contextual factors that might not otherwise be apparent. Observational techniques can provide a relatively objective measurement of behaviour compared with self-reports and consequently the researcher is not solely reliant on what research participants say they do. However, Patton (2002) lists several limitations of the approach. The very presence of an observer may affect how those observed behave, often in unknown ways. Observers introduce their own bias (such as failing to notice things or ignoring things not considered relevant). They are physically unable to observe large populations and may miss some content of interest. Conversely, a considerable amount of data that later proves to be irrelevant to the research questions may be collected. Although outward behaviour is observed and recorded, the reasons for it may be unclear or misconstrued. Finally, both data collection and analysis can be time consuming.

6.4 Research instruments

6.4.1 Questionnaire development

Both the student and teacher questionnaires were kept short to maintain interest and maximise participation rates. A mix of closed questions (for speed and ease of completion and comparison) and open questions (less vulnerable to researcher preconceptions and able to elicit information that might otherwise be missed) was used. The student questionnaire took about 10 minutes to complete (although this varied considerably) and had only two open-ended questions (with three of the closed questions having a facility to write in an ‘other’ response). The teacher questionnaire was similar in structure, with two fully open questions, and took about the same amount of time.

The questionnaires were constructed using widely accepted principles of good practice (see for example Johnson & Turner, 2003). These included matching the items to the research objectives; using natural and familiar language (especially important for the students); making the items simple, clear and precise; phrasing them in a way that avoided leading or bias; and ensuring the possible responses for closed questions were mutually exclusive and exhaustive (or had an ‘other’ option). Enough space was provided beneath open questions to allow completion without seeming too daunting (de Vaus, 2002). The needs of the less literate as well as those with English as an additional language were constantly considered.

Both questionnaires were carefully designed to fit on two pages of A4 so they could be printed as one double-sided sheet. This makes them look less intimidating or time-consuming to fill in (as well as being more environmentally friendly). Coloured paper was used to improve the chances of them standing out from teachers' other paperwork.

The teacher and student questionnaires were both piloted before being finalised to optimise validity – ie, to check that they were measuring what they were designed to measure.

6.4.2 Pilot teacher questionnaire

This section explains the reason for each question that was asked. The full questionnaire in its original order can be found in Appendix 1.1 (Science teachers) and 1.2 (RE teachers).

The questionnaire began, as recommended in the literature, with innocuous questions that would draw the respondent into the research (Cohen, Manion, & Morrison, 2007; Gorard, 2003). They established the respondent's current experience of teaching about the origin of life and what form it took (in terms of level, time and coverage):

> Q1 In your science/RE/RS lessons, do you cover the origins of life - how life on earth as we know it today came into being?
>
> Q2 Approximately how many hours do you spend on it at: (KS3; KS4; KS5)
>
> Q3 Which of the following do you usually mention during your teaching of this topic? (religious beliefs about creation; Darwin's theory of evolution; other scientific theories (eg Lamarck))

Contextual questions of a rather more sensitive nature, exploring the respondents' religious faith and the faith, if any, of the school, were kept to the end of the survey to increase the likelihood of them being completed. Asking personal questions, which some may regard as intrusive, is best left until the end of the questionnaire. This reduces the likelihood that respondents will withdraw from the process completely, because they have already invested time and effort in the survey (Gorard, 2003). These questions were chosen to represent factors that might help with interpretation or enable analytical comparisons between the Science and RE teacher sub-samples. For the potentially delicate questions about religious belief 'prefer not to answer' categories were included. The wording was as follows:

Q11 How would you describe your religious faith? (Tick one box only) (No faith, Buddhist, Christian, Hindu, Jewish, Muslim, Sikh, Other - write in, not sure, prefer not to answer)

Q12 Would you say that nowadays you are …? (Tick one box only) (scale: very religious; somewhat religious; not very religious; not at all religious; prefer not to answer)

Q13 Is your school … (Non-faith; Church of England; Roman Catholic; Muslim; Jewish; Other - write in)

Respondents were asked both about their personal perceptions and actual experiences of the origin of life as a contentious topic. Where rating scales were used, monotonic rather than bipolar scales were adopted – that is, ones that increase continuously rather than ‘mirror image’ scales with a ‘flip over’ point (Low, 1988). The scales were unidimensional and presented as five tick boxes with a two-headed arrow across the top. Only the end points were labelled to avoid semantic difficulties in naming each point (see Appendices 1.1 and 1.2). Although technically there was no midpoint in the scales, respondents may have perceived one to exist between, for instance, ‘very’ to ‘not at all’ controversial. This raises issues in both data collection (the ‘central tendency’ problem of respondents opting to sit on the fence) and analysis (those with a genuinely neutral stance being conflated with those who have no opinion or do not understand the question) (Muijs, 2004):

Q4 How controversial do you personally think this topic is? (very controversial to not at all controversial)

Q5 Have you ever found this topic controversial in your classroom? (yes/no)

Q6 If yes, please give some detail (reasons why, frequency etc)

All teachers were then asked how important they considered the coverage of religious explanations of the origin of life in the science curriculum:

Q7 How important is it to cover religious beliefs about the origin of life in the science classroom? (essential to not at all important)

Q8 Please explain briefly the reasons behind your answer at Q7.

To explore levels of confidence in covering explanations outside their subject area, teachers were asked:

Q9 Science teachers: How confident do you feel about covering religious beliefs about the origin of life in the science classroom? (very confident to not at all confident)

OR Q9 RE teachers: How confident do you feel about covering scientific theories about the origin of life in the RE/RS classroom? (very confident to not at all confident)

Establishing teachers' personal viewpoint as regards the origin of life is a complex area and the nature of the sample meant there could be a range of sophisticated theological or scientific opinions. Lack of space precluded the administration of a battery of questions such as the 20-item measure of acceptance designed for US teachers by Rutledge & Warden (2000), the 15 items about evolution used with an international sample of teachers (Clément & Quessada, 2008) or the 17 items used by Lawson and Worsnop (1992) to explore students' viewpoints regarding evolution and creationism. Furthermore, to allow later comparison of the teacher and student samples, the approach needed to be clear and simple enough for teenage respondents.

These requirements for concision and simplicity were met by adapting a question about the origin of human beings that has been used extensively with the US public since 1982 (Gallup, 2006) and was adopted more recently in the UK by the BBC (BBC/MORI, 2006). Although it can be criticised as a crude measure (eg Jones & Reiss, 2007), the previous surveys show that respondents are able to choose between the options suggesting they are comprehensible and meaningful to lay people, and it would allow some comparison with the general public. In line with best practice discussed in Section 4.1.1, an "other" answer category was included to provide participants more latitude in response.

For this study, the wording was changed in two main ways. Firstly, the position of direct creation by God was not limited to being within the last ten thousand years. The imposition of such a timeframe tends to be characteristic of a Christian perspective and many Muslims who believe in direct creation by God do not dispute the age of the earth (Section 2.1). Secondly, the three statements were not labelled 'creationism', 'intelligent design' or 'evolution' as in the BBC poll, because it was felt that teachers in particular might baulk at such a superficial definition of complex positions. The final wording for the pilot survey was:

Q10 Which of these 3 explanations comes closest to describing how you think life on earth came into being? (Tick one box only)

Human beings were created by God pretty much in their present form.

Human beings have developed over millions of years from less advanced forms of life. God had some part in this process.

Human beings have developed over millions of years from less advanced forms of life. God had no part in this process.

Other - please give details

At the very end, respondents were asked if they had any suggestions to help improve the questionnaire:

> Q14 Finally, this is a pilot survey. If you have any comments that might be useful in designing the final questionnaire – for instance, questions that were unclear or difficult to answer – they would be gratefully received.

6.4.3 Pilot student questionnaire

The first question on the student questionnaire (see Appendix 1.3) was designed to elicit respondents' own standpoint on the origin of life; the second to explore their knowledge of alternative explanations. Both questions were open-ended to avoid the danger of a predetermined list of responses constraining students' answers or imposing researcher preconceptions on them. The questions were carefully phrased so they were not aligned with any particular worldview - for example, using the verb 'developed' in relation to how life originated might presuppose evolutionary thinking, whereas the verb 'created' would be more akin to religious viewpoints. The wording was intended to indicate the focus on the origin of life, not the origin of the universe:

> Q1 Can you describe how you think life on earth as we know it today (with humans, animals and plants) came into being?
>
> Q2 Are you aware of any other explanations of how life on earth as we know it today came into being? If so, please describe them.

Having expressed their opinions in free writing, students were then asked to select one of three options that described how human life may have originated. In line with the teacher questionnaire, the wording was based on the 2006 BBC/MORI survey:

> Q3 Which of these 3 explanations comes closest to describing how you think life on earth came into being? (Tick one box only)
>
> Human beings were created by God pretty much in their present form.
>
> Human beings have developed over millions of years from less advanced forms of life. God had some part in this process.
>
> Human beings have developed over millions of years from less advanced forms of life. God had no part in this process.
>
> Don't know/not sure

The face-to-face qualitative work was expected to be the main arena for examining differences between students' own religious or cultural beliefs about the origin of life and what they were taught in school, but the survey provided an opportunity to gain ancillary information. One question was designed to gauge how much influence their teachers might have relative to other factors. The list of possible answers was based on the Woods and Scharmann (2001) study of over 500 US high school students who described the most important influences on their attitudes to evolution as theological (God, religion etc) or personal (family, friends, teachers). Others mentioned the media, evidence and (lack of) proof. The questions were intended to measure how far they felt ‘in tune’ with their teachers compared to other groups:

> Q4 Which of the following has had **the most** influence on your views about how you think life on earth came into being? (Please choose just one answer if you can.) (My family; My teachers; My friends; My religion; The media (eg TV); Other - please write in)
>
> Q5 In terms of the people and groups you come across, how many of them do you think agree with your beliefs on this topic? (Separate answers for My family; My teachers; My friends; scale: all of them agree, most of them agree, some of them agree, none of them agree, don’t know)

Finally, students were asked contextual and demographic questions about their religious faith and religiosity (using the same wording as in the teacher questionnaire), and their gender, for possible later use as variables in analysis:

> Q6 How would you describe your religious faith? (Tick one box only)
>
> Q7 Would you say that nowadays you are …? (Tick one box only) (scale: very religious; somewhat religious; not very religious; not at all religious; prefer not to answer)
>
> Q8 Are you male or female?

6.4.4 Teacher interview schedule

Although schedules of questions were compiled prior to the interviews (see Appendix 1.7) these were used as a framework and not followed in a standardised manner. Instead, the exact wording and sequence in each situation was guided by the nature of the responses and trajectory of the discussion to achieve good flow and coverage. This equates to what Patton (2002) termed the “interview guide approach”. He summarised it as enabling an element of systematic rigour, by ensuring comprehensive coverage, whilst maintaining an interview flexible enough to adapt to circumstances and keeping a more informal, conversational feel. The main danger is that interviewer flexibility over question wording and order might affect responses, leading to a reduction in comparability between participants.

This less rigid format was in keeping with grounded theory principles of introducing changes during the process to reflect what is emerging from the data. It must be recognised that using *post-hoc* analytical themes might result in information emerging as important too late in the procedure to check with all participants. This is why it is imperative to do at least some preliminary analysis during the fieldwork so that any major unanticipated themes can be incorporated in subsequent encounters.

The pre-planned interview schedule began by exploring whether the teachers acknowledged an inter-relationship between science and religion, and if so, where it was apparent:

> How would you describe the inter-relationship between science and religion?
>
> Where is the inter-relationship most evident? Anywhere else?

To help assess how much the inter-relationship actually featured in their everyday teaching, more specific experiences in their own classroom were probed:

> Do you address it explicitly in your teaching? If so, where?
>
> Does it ever get raised spontaneously by the students? Examples?

The interview then focused on how they taught the origin of life in their classroom and whether this was affected by their own position on the topic. These questions were an attempt to illuminate any differences between how the origin of life is dealt with in Science and RE classrooms:

> What do you teach about the origins of life? (prompt if necessary about present day life on earth)
>
> What do you yourself think about how life originated?
>
> How do you think your own beliefs affect how you teach this topic?

They were asked whether the topic had ever caused controversy among the students. This would provide a useful source of triangulation with both the similar question in the teacher survey and with feedback from discussions with students. They were also asked whether it had ever been controversial among the staff:

> Has it ever proved controversial in the classroom during your teaching career? If so, examples
>
> Has it ever proved controversial in the staffroom? If so, examples

A question about whether teachers felt adequately supported to deal with the topic was designed to find out whether there was an unmet demand for professional development or training in the area:

> Do you feel the need for any further support in this area? If so, what kind of thing (eg professional development)?

To investigate cross-curricular links, the extent and nature of the relationship between the Science and RE departments in their current school and any others they had taught in was probed:

> Can you describe what collaboration there is in this school between Science and RE departments?
>
> What contact do you personally have with the Science/RE dept?
>
> How does this compare with previous experiences at other schools?

Teachers were then asked to summarise their views about the relationship between science and religion and how it should be tackled in school:

> (How would you summarise) your own personal views about
>
> a) whether the science/religion overlap should be tackled in school
>
> b) how it should be tackled eg where in curriculum, what ages, what kind of teaching approach, resources etc.

At the very end of the interview, they were invited to talk about their broader spiritual beliefs to give additional context. This was the final substantive question for two reasons: likelihood to answer should be high because trust and rapport would have been built up during the interview; but by this late stage, even if the question was considered too intrusive it did not jeopardise data collection:

> (Stress don't have to respond) Would you like to say something about any religion, faith or spiritual beliefs you have?

Finally, teachers were asked some questions about their own background – the nature of their degree discipline, how long they had been in teaching and (for Science teachers) whether they had a particular subject specialism.

In one school, a focus group rather than an interview was conducted with Science teachers, and the topic guide was adjusted accordingly (see Appendix 1.8).

6.4.5 Student schedule

At the beginning of the session, the students were given a concise but thorough introduction which outlined the background to the research, clarified the role and responsibilities of researcher and participants, and established ground rules for the discussion.

In the early stages, whilst rapport was being established, they were asked questions with a factual rather than opinion base. To explore the research question concerning the difference between the approach in Science and RE, they were initially asked what they had learnt about the origin of life and the pedagogical approach(es) used:

> In school, what have you learnt about how life on earth as we know it today came into being? (prompt if necessary to cover scientific, religious and any other explanations)
>
> How has it been taught to you eg textbooks, discussions, teacher standing in front of class talking (separate out different subjects eg Science, RE)

Those who remembered it being covered in more than one discipline were asked to reflect on similarities and differences between the treatments and how they dealt with this:

> Probe any conflict between how it has been covered in different subjects or lessons and how this has been handled. Prompt if necessary: do the explanations seem to fit together well or do they contradict each other?

The aim was to explore the interaction between their own beliefs about the origin of life and what they were taught at school, without initiating a defensive response. The questions used to promote discussion were therefore quite indirect:

> Is it a topic you have ever come across outside school? If so, probe for: where and in what way?
>
> Do you think it is a controversial subject? If so, probe for: why? in what way?

The final section of the discussion was designed to explore students' opinions about the relationship between science and religion more broadly, although it was anticipated that at this stage they would be willing and able to relate this to their own standpoints about the origin of life:

> Thinking of school specifically – is there any interaction between science and religion? Details? Probe for: Separate? Related? Opposed?
>
> Do you think there is a science/religion inter-relationship in the world at large? Probe for: Separate? Related? Opposed?

Finally, to provide some variation, and to cater for those who expressed themselves more readily non-verbally, they were asked to illustrate the inter-relationship diagrammatically. Based on Reiss (2008a), they were shown example schemata on which they could build their own response, and then asked to explain what they had drawn.

In the spirit of the iterative nature of grounded theory (Bryman, 2008) some changes were made to the interview guides after reflection on initial data collection and early analysis.

Fieldwork with students at Schools B and C took place several months before Schools A and D, allowing the introduction of some extra questions as a result of ideas arising from the earlier phase. However, it meant that the issues were not explored with students at Schools B and C except in those instances where they had been mentioned spontaneously. There were two main examples of this process. Firstly, it became apparent that some participants found the nature of the discussion rather abstract or even irrelevant. In an attempt to draw them in, I experimented with presenting a hypothetical scenario and asking for their reactions. This tactic worked well and was adopted in later focus groups (mainly Schools A and D):

> If you were a Science teacher and someone in your class said they didn't believe the scientific explanation because of their religious beliefs, what would you say to them?

Secondly, a participant's narrative about how they had changed their opinion on the topic opened up a potentially interesting avenue for exploration. Therefore, later groups incorporated a question about consistency of viewpoint:

> Have any of you changed your minds about how life on earth came into being? If so, why?

The full discussion guide can be found in Appendix 1.9.

6.4.6 Observation schedule

Lesson observations were included as part of the research design to explore the question of how coverage of origin of life varies between Science and RE classrooms, in terms of both content and pedagogical approach. As a preliminary, a small number of lessons were observed and detailed field notes taken. At the same time, an observation schedule was piloted. This recorded coverage (eg what theories and explanations were mentioned; in what detail; whether there was explicit exploration of the inter-relationship between science and religion); pedagogy (use of different teaching tools, styles and techniques); and student engagement. However, it became clear that completing sufficient observations within the available time frame would be impossible and this source of data was not pursued. Moreover, I felt that the effect of being observed on both students and teachers meant that any data I did collect would not be a reliable indicator of how the topic was usually covered in the classroom.

6.5 Pilot study

The student and teacher questionnaires were piloted to ensure that the questions were understood as intended and that the topics covered were adequate to answer the research questions. Student questionnaires were piloted in a sixth form college chosen because it was mixed in terms of the cultural background and ability of respondents. Moreover, their tutor was a personal contact who was interested in the topic and willing to administer the survey and report any feedback. Although the students were a year or two older than the intended main sample, the breadth of their background and immediate availability were judged to outweigh this drawback. The sample consisted of 32 male and female students who were studying AS or A level biology.

The Science teachers who took part in the pilot were contacts from schools in the local area who were attending a meeting at the university, plus the departmental staff at case school C. They all taught science at secondary level. The RE teachers were from a local secondary school.

The main reason for conducting the pilot study was to refine the research instruments, therefore the findings are only reported here insofar as they affected development of the main study. For these purposes, a handcount of closed questions and visual scrutiny of open answers sufficed. After completion of the pilot phase, the decision was taken that the nature of the pilot teacher sample, and the questions asked, remained sufficiently similar to be incorporated with the main part of the study for analysis.

6.5.1 Changes after piloting: teacher survey

Three questions were added to the teacher survey to make the data more complete. One asked how much collaboration there was between the Science and RE departments (on a five-point scale from ‘a lot’ to ‘none at all’). The other two (gender and length of teaching experience) added two more variables for potential use in analysis.

Some of the pilot questions were amended. The mention of ‘God’ in the response options about how human beings originated (pilot Q10) was changed to ‘a divine being’ to allow for those who expressed belief in the involvement of something supernatural but would not describe that being as ‘God’ (eg one of the sample was Pagan and changed the wording to ‘a god’). It was also pointed out that the assertion ‘God had no part in this process’ presupposed the existence of God, and consequently this statement was changed further, to read ‘No divine being had a part in this process’.

The wording “religious faith” in Q11 was changed to ‘religious beliefs’ to be more encompassing (following the input from a Buddhist that theirs was a belief, not a faith). Finally, the question asking respondents to define ‘how religious’ they were (Q12) was changed to ask about the ‘strength of belief’ to be both less ambiguous and consistent with the changes to the preceding question.

There was some fine-tuning in relation to layout. Boxes were replaced by lines at Q2 (time spent on origins of life at different Key Stages) to encourage figures to be written in, and

'PTO' added to the bottom of the page to reduce the likelihood of respondents missing the second page.

The final questionnaire can be found in Appendices 1.4 and 1.5.

6.5.2 Changes after piloting: student survey

Although students completed the pilot study without undue difficulty, some adjustments were made to the questionnaire as a result of comments and advice from teachers, or to bring it into line with changes to the teacher questionnaire. These differences in the final instrument, along with the older age profile of the pilot sample, meant that the pilot and main student surveys were not combined.

There were no objections to the survey in terms of length or content: the students took about ten minutes to complete the form and none of them refused to participate.

The students came from a range of religious backgrounds. There were seven Muslims, four Christians and one Hindu. Twelve said they had no faith and six were not sure. One ticked 'other' and described her/himself as 'atheist'. Eight of the 12 who followed a religion described themselves as very or somewhat religious: three of the four Christians said they were not very or not at all religious.

The first two questions were shortened and simplified on the advice of a teacher at one of the case schools who judged that the subordinate clauses and parenthetic text might be unduly complicated for less able students and those with English as an additional language. They became:

> How do you think life on earth came into being?
>
> Do you know of any other explanations about how life on earth came into being? If so, please describe them.

Despite the qualifying text in the pilot and spoken guidance from the tutor, several students referred to the big bang instead of, or as well as, evolution as an explanation for how life on earth came into being. This suggested the misinterpretation was more a result of a fundamental student misunderstanding than ambiguity in the question, and that this was unlikely to be addressed through further refinement of the wording. The answers also revealed some confusion about the mechanisms of evolution, but as this was not a focus of the research it will not be considered further here.

What was of relevance to the development of the study was the breadth of opinion within the sample even though they attended the same, non-faith, educational institution. Although the largest group adhered to a scientific explanation for the origin of life and of humans specifically, a sizeable minority believed that different species had been created directly by God, and others thought there was a combination of scientific process and divine involvement:

> *God created man and everything in this world. God created everything, the whole universe. God put a man (Adam) and woman onto earth and they produced mankind. The same with all organisms.* Muslim female
>
> *Big bang theory followed by evolution.* Christian female
>
> *I think life started by God creating animals and plants.* Christian male

In line with the above, when students were asked to choose between three explanations for how human life on earth came into being, the most popular answer was evolution without the involvement of God (15). However, several students thought there was a divine dimension, either in combination with evolution (6) or with God as direct creator (7). There was a tendency for Muslims to hold a creationist viewpoint whereas Christians were more varied in their position. These types of response reinforced my initial intention to sample case schools that would include students from both Christian and Muslim faith traditions.

Only 11 students thought all or most of their teachers would agree with their views on this topic, with 9 saying they did not know (Table 6.2). In contrast, the majority (22/31) were confident that all or most of their family would agree with them and slightly fewer (17/31) said the same about their friends. Only small numbers (4 and 1 respectively) did not know what these latter groups might think. The discrepancy in the figures for "don't know" suggested a problem with the element of this question asking about teachers. It was hypothesised that students found it difficult partly because schools contain dozens of staff potentially with dozens of different viewpoints: rightly, students would not see them as a cohesive group with a single view. The question was changed to ask only about those dealing with the two subjects of particular interest in this study: teachers of Science and teachers of RE.

Table 6.2: Level of agreement with viewpoint

	all	most	some	none	DK
My family	12	10	5	0	4
My teachers	2	9	11	0	9
My friends	2	15	12	1	1

Base: all respondents – raw numbers
Q5 In terms of the people and groups you come across, how many of them do you think agree with your beliefs on this topic?

The questions about respondents' religious faith (its type and strength) were changed in line with the teacher questionnaire (Section 6.5.1). The wording about 'God' at Q3 (how humans had come into being) was left unaltered, because it did not seem to raise the same issues as it had for teachers and substituting ‘divine being’ might have caused confusion. However, the ‘don’t know’ option was replaced with ‘other’ to match the teacher survey.

On the advice of a teacher, the font was changed from Times New Roman to Comic Sans to be more accessible to young people. The introduction was shortened so there was less to read. The instruction ‘please turn over’ was added at the foot of the first page to maximise the proportion of students completing both sides.

The final questionnaire can be found in Appendix 1.6.

6.6 Main study

6.6.1 Teacher survey

The finalised instrument was distributed by post. This approach was preferred because it enabled a national probability sample, which should represent schools with a range of characteristics that might influence responses, to be contacted. Administering the questionnaire in person (either face-to-face or by telephone), although it might have increased response rates, was unfeasible in terms of time and expense. A concise covering letter is important to encourage replies (Cohen, Manion & Morrison, 2007): it outlined the background to the research and the confidentiality of responses (Appendix 1.4).

The sample was drawn using a disproportionate stratified random sampling design. Stratification was by local authority (143 authorities across England, having excluded those with fewer than eight secondary schools) and one school was chosen at random from each. Although this over-represented smaller authorities, it was felt to be appropriate because the RE syllabus, being locally agreed, would vary by authority (Section 3.3.2).

The list of schools in each authority was identified using a government website[3] and a random number generator[4] was used to choose one from each list. Once the sample of schools was drawn, the information on their websites was used to identify the head of department by name wherever possible as this is the recommended best practice (Verma & Mallick, 1999). The names of 32 (out of 72) heads or leaders of Science or Biology and

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[3] http://schoolsfinder.direct.gov.uk/

[4] Random number generator operated by the National association of advisors for computers in education (Naace) http://www.mape.org.uk/activities/index.htm

23 (out of 71) heads or leaders of RE or Religious Studies (RS) were found. For the remaining schools, the relevant person was addressed as accurately as possible (eg often the website distinguished whether the school used the term Religious Education or Religious Studies; whether they had a head/leader of Biology or just a head of Science). The sampling process is summarised in Figure 6.2.

Low response rate proved to be a particular problem at 34% for RE teachers and only 14% for Science teachers. Although the survey was deliberately sent out at a quieter time of year (towards the end of the summer term when a proportion of students would be absent after exams) workload pressures may have prevented it from being completed. Also, the topic may not have been considered a particularly salient one. A range of 'average' response rates to postal surveys have been cited, from as low as 20% up to 80% (Cohen, Manion, & Morrison, 2007; Gorard, 2003). There is a feeling within the educational research field that it is becoming increasingly difficult to persuade teachers and schools to participate in research (National Foundation for Education Research, personal communication). Although they have been shown to increase response rates (Cohen, Manion, & Morrison, 2007; Muijs, 2004; Verma & Mallick, 1999), reminders were not sent out in this study for reasons of cost and practicality (virtually the whole sample would have had to be re-contacted because they did not have to provide their names when replying).

The low response rate is important because it means that those who answered cannot be assumed to be representative of the sample as a whole, so the findings cannot be generalised. In effect, although the sample was drawn using a stratified random sampling design, the final pool of respondents represents a volunteer sample within that. In other words, the differential return rates meant the final sample was not unbiased.

Opportunistic samples were subsequently contacted to boost the numbers. They were obtained in two ways:

- teachers attending meetings at the university. They were all mentors to trainee teachers in either Science or RE. Although representative of a small area geographically (about 35 miles radius), they were less self-selecting in terms of interest in the topic than respondents gained via the other sampling methods, as they were a captive audience and only one of them failed to take part;
- RE teachers who responded to an email request from a national professional organisation (NATRE, the National Association of Teachers of Religious Education): more geographically spread but also potentially the most self-selecting of all the sub-samples in terms of being motivated by interest in the topic (plus belonging to the association and have access to the internet).

The different techniques used for the Science and RE sub-samples has resulted in the RE group being more self-selecting (dominated by those who chose to respond to a postal or online questionnaire). The Science teachers, on the other hand, were predominantly attendees at a mentors' meeting or members of staff at School C, who all participated in the pilot when requested. The breakdown is shown in Table 6.3 (overleaf). There were also responses from eight science and 15 RE teachers who did not currently cover the origin of life. They have been excluded from the analysis.

Figure 6.2: Constructing the teacher survey sample

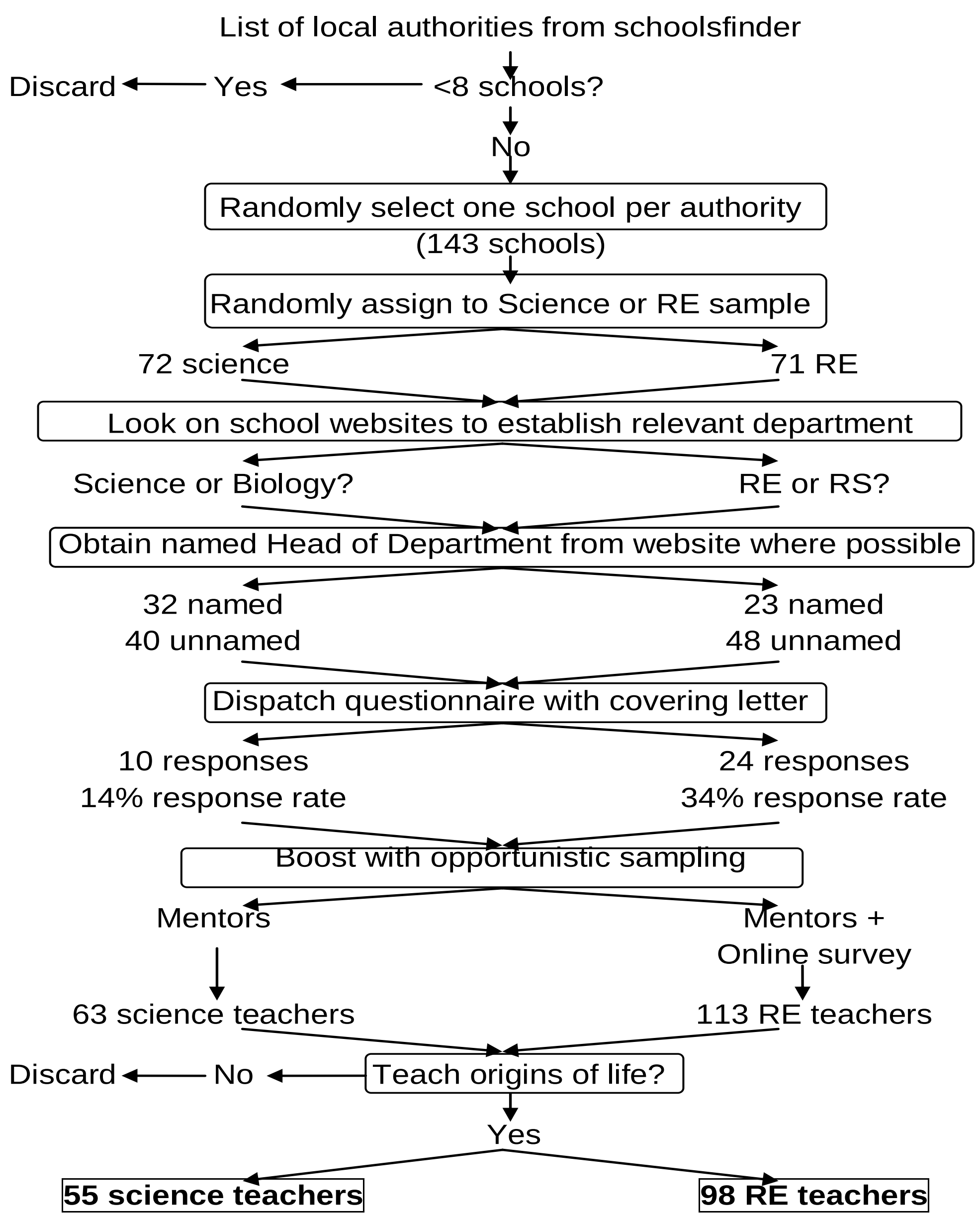


Table 6.3: Teacher survey responses by data collection method

	Science teachers	RE teachers
Pilot	26	3
Random sampling	10	24
Mentors	19	6
Online	na	65
Total	**55**	**98**

Base: all those teaching origins of life – raw numbers

6.6.2 Case schools

The initial intention was to select three cases. These were chosen using theoretical sampling designed, in the words of Corbin and Strauss (2008), to ensure collection of data "from places, people, and events that will maximize opportunities to develop concepts in terms of their properties and dimensions ..." (p. 143):

School A: Christian faith school

School B: non-faith school with a catchment of mainly Muslim families

School C: non-faith school where pupils are not known to come from any particular religious background

The rationale was that, in Schools A and B, I could expect to find a significant number of students belonging to faiths that include followers who have rejected some of the scientific explanations about the origin of life. Certainly, prior discussion with teaching staff had established that the science was always taught with an awareness of possible religious sensitivities. In School C, the mix of those with and without religious beliefs was more likely to be representative of the majority of secondary schools in England. All the schools were state maintained, so they followed the National Curriculum.

School C was undergoing change in the senior management team during the research period, and it was only possible to complete the qualitative phase with the students. Examination of the data already collected showed that theoretical saturation had not yet been achieved, ie there were not enough data on this type of school to be confident that further sampling would not throw up new categories. To compensate, School D was recruited as a substitute, as it also fitted the profile of non-faith school where pupils are not known to come from any particular religious background. Further detail of the school characteristics can be found in Table 6.4.

Table 6.4: Profile of case schools

	School A	School B	School C	School D
Size	801 - 1000	1201 - 1400	801 – 1000	1001 – 1200
Location	Urban	Inner city	Suburban	Rural
Type of school	Comprehensive, mixed, voluntary aided	Comprehensive, girls, community	Comprehensive, mixed, community	Comprehensive, mixed, community
Sixth form	yes	yes	no	no
Pupil background	Around 80% white British; mostly Christian backgrounds	Predominantly Bangladeshi Muslim heritage with English as an additional language	Fewer than 5% from minority ethnic groups	Fewer than 5% from minority ethnic groups
Catchment	Wide range of social and economic backgrounds but generally ‘favourable’	Area of high social and economic disadvantage	Area of high social and economic disadvantage	Wide catchment area
A*-C GCSE (incl maths and English) 2008	51 – 60%	51 – 60%	31 – 40%	61 – 70%
Free school meals†	Below average	5X average	2X average	Below average

† national average is 13.4% eligible in secondary schools (DCSF, 2009)
Source: Ofsted reports and school websites

The four case schools were all approached via specific members of their staff who were contacts either from previous research (School B) or from my departmental colleagues (Schools A, C and D). In three cases the main point of entry was through the science department, in one case (School A) it was through the Head of RE. Where necessary (in three out of the four schools), these contacts negotiated permission for the school to take part in the research from the main gatekeeper ie the head teacher.

In ideal circumstances, I would have introduced the survey to students in a lesson unrelated to the topic (eg citizenship) and then withdrawn whilst they completed the questionnaire. In practice, this was not possible. All surveys were completed during school time, but students either performed the task in RE (School A) or Science (Schools B and D). Sometimes the teachers administered the questionnaire. In these conditions, I had no control over the consistency of the introduction even though I provided a brief script.

The teachers were relied upon to select combinations of students for the face-to-face sessions, using their knowledge of which groupings would provide favourable dynamics. At the first school (C), students were interviewed in pairs. However, this was not always effective because of some reluctance to engage, and the numbers were expanded to small groups (usually of 3 or 4) in subsequent schools to increase the likelihood of having at least one member willing to kick start the discussion. The students were drawn from RE classes (School A), Science classes (School C) or a mix of both (School B). In School D, the groups were convened in students' free time with one organised by the Head of RE, and the other by me directly. Lack of space meant that fieldwork sometimes had to be conducted in the same room as the lesson, resulting in problems from background noise.

With the exception of School C, at least one Science and one RE teacher was interviewed at each of the case schools (Table 6.5). This was usually done individually and face-to-face (by phone in one instance). The original intention was to interview more teachers per department, but it proved difficult to get volunteers or arrange times, so the head of department was chosen as having more of an overview. In one school, a departmental focus group was conducted during lunchtime but – although it yielded useful data – it was hampered by excessive informality (teachers coming and going; nowhere to sit; background noise; over-talking etc). The pilot lesson observations were conducted in Schools B and D.

Table 6.5: Teacher interviews by school

	Science teachers	RE teachers	Science observation	RE observation
School A	1	1	0	0
School B	1	2	1	0
School C	na	na	na	na
School D	1 (FG)	1	1	2
Total	**3**	**3**	**2**	**2**

Base: numbers of interviews/focus groups

The student questionnaire was completed by over 200 students: respondents from two mixed ability RE classes in School A; students from a range of science ability groups in School B; and in School D, the Science department administered the survey to the majority of the year group (Table 6.6).

Table 6.6: Student survey responses by school

School A	41
School B	30
School C	na
School D	138
Total	**209**

Base: Students – raw numbers

Students at all four case schools were involved in the qualitative stage, either in pairs (School C) or small focus groups (Schools A, B and D). As with the survey, a range of abilities was represented (Table 6.7).

Table 6.7: Student discussions by school

	Number of pairs/groups	Number of students
School A	6	21
School B	5	14
School C	10	20
School D	2	9
Total	**23**	**64**

Base: Raw numbers

6.6.3 Timeline of fieldwork

The pilot surveys were conducted in the last two months of 2007. Most of the data collection for the main questionnaire study with teachers was carried out in summer and autumn 2008. The final phase of fieldwork was an attempt to increase the sample of Science teachers by distributing the questionnaire at a mentors' meeting in summer 2009. Each case school was visited across one or two terms between summer 2008 and spring 2009 to gather data from students and teachers. Table 6.8 shows the timeframe of the fieldwork.

Table 6.8: Fieldwork timings

	Autumn term 2007	Spring term 2008	Summer term 2008	Autumn term 2008	Spring term 2009	Summer term 2009
Survey	teacher + student pilot		postal teacher	RE/Science mentors + RE online		Science mentors
School A				students: survey and discussions	students: discussions	
School B			students: survey and discussions			
School C			students: discussions			
School D				students: survey	students: discussions	

6.7 Analysis methods

As a consequence of using a mixed methods approach, more than one analysis technique was used in this study. However, grounded theory provided the main theoretical underpinning for the analysis. Section 6.1.2 gave the justification for adopting this approach and a summary of which elements of grounded theory were incorporated. This section outlines the framework of the analysis in more detail. Although the process is described as clearly as possible, it should be recognised that, in the words of Corbin and Strauss (2008) "something occurs when doing analysis that is beyond the ability of a person to articulate or explain" (p. 9).

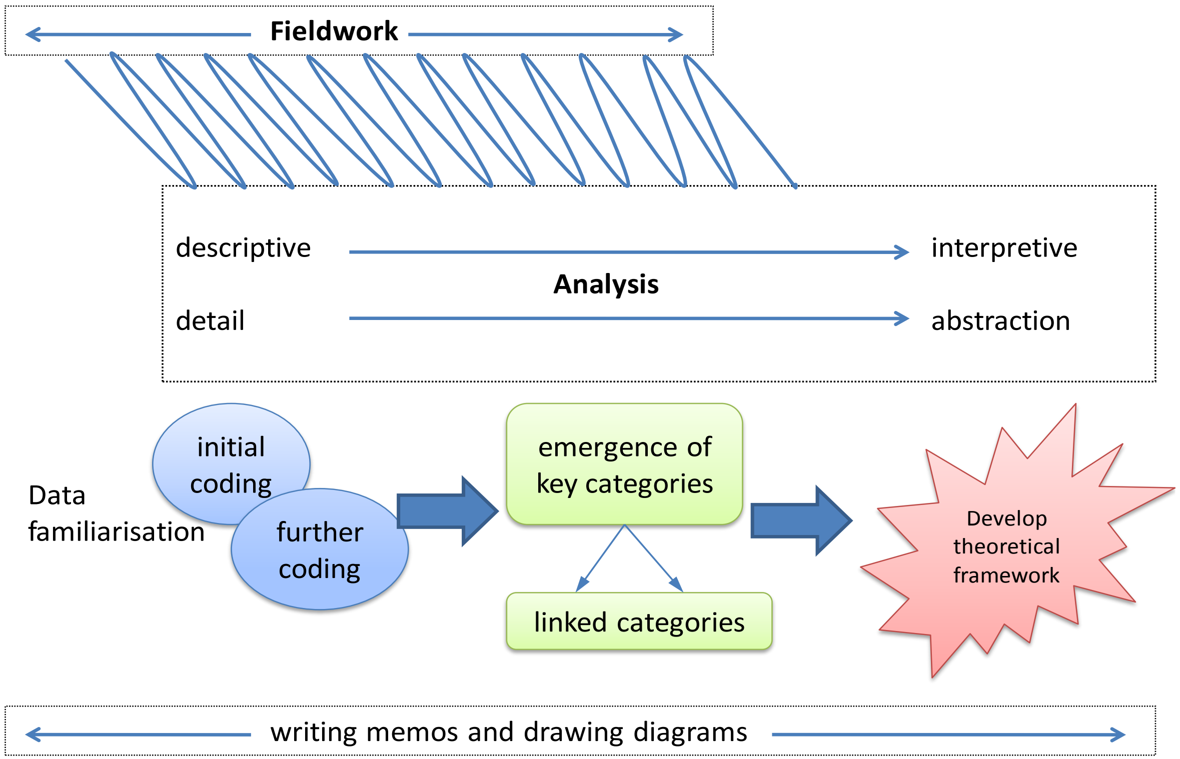
The iterative and non-linear nature of the analysis is illustrated in Figure 6.3.

6.7.1 Using grounded theory

At the outset, the individual transcripts were examined at a detailed level for emerging themes or concepts, using participants' own language when possible (what Corbin and Strauss (2008) refer to as 'open coding'). This is demonstrated by the following passages, with the initial 'open' codes shown in italics beneath each block of speech. Even at this stage, many of the categories (eg 'nature of science') had sub-categories or 'properties' (Corbin & Strauss, 2008). The fine-grained codes provide a source of illuminating detail after later conflation into more abstract categories:

> S: In science he told us like it was a fact, in RE he told us it like as a discussion. He was, "this is how the world was made, what do you reckon?" kind of thing
>
> Codes*: nature of science - fact; nature of RE – debatable; teaching approach - discussion*
>
> S: Yeah, most people had different opinions on how it was created. Some of us believed the science, some believed in God, some believed in a mix of them both so – it just depends on how you were brought up I suppose.
>
> Codes*: divided opinions; viewpoint - science; - religion; - mix of science/religion; viewpoint factor - upbringing*
>
> S: Yeah, in science it's not really that open to opinion and in RE you can say whatever.
>
> S: I don't think science is ...
>
> S: It's basically about facts
>
> S: Well it depends because all about GM crops and that we have discussions about that, whether it's right or wrong.
>
> Codes*: nature of science - fact; - closed; nature of RE - open; - debatable; nature of science - open; teaching approach - discussion*

Figure 6.3: Analytical process using grounded theory



As this initial open coding was being carried out, patterns emerged through which codes could be connected into wider analytical categories and over-arching themes. For instance, a key theme of 'nature of knowledge' was developing, whereby science tended to be linked with fact, proof and evidence whereas RE was associated more with belief, opinion and openness. Co-occurrence of codes showed a clustering of teaching methods: science seemed to be based around teacher instruction and textbooks, whilst RE featured debates and discussion. These two procedures – the preliminary, open coding and the inter-relating of concepts – progressed alongside each other for much of the time. Consequently, in Figure 6.3 they are described as 'initial' and 'further' coding and shown as overlapping.

Of paramount importance in developing a grounded theory is the eventual identification of a 'core' (Glaser, 1978) or 'central' (Corbin & Strauss, 2008) category which is the main theme underlying the data. Once isolated, this is used as a lens through which to conceptualise and construct the theory. Corbin and Strauss, among others, imply that it is best to have just one of these: "Having two central categories means developing two different theories ... usually if a researcher looks hard enough at the data, he or she can come up with one unifying idea" (p. 105). To me, this constraint seemed artificial and out of keeping with the otherwise data-driven nature of grounded theory, and therefore having a single emerging theme was not a stricture I imposed on myself in advance.

Like many other methods of qualitative data analysis, there is a risk with grounded theory that the data become so detached from the actual fieldwork that the meaning can suffer. This is why it is essential to bear in mind what interview any selected quote emanated from and its surrounding context. Because this data set was relatively small, and computer software was used to assist with analysis, it was easy to refer back to the broader context whenever there seemed a danger that an excerpt might become too divorced from its original setting.

The computer software program that was available through my university was Atlas.ti. It has been extensively used to help manage qualitative analysis in a variety of social science research studies (Pope, Ziebland & Mays, 2000). Essentially, using a software package such as this saves time by doing electronically what would otherwise have to be performed manually. It does not remove the need for data immersion, creative and rigorous coding and intellectual analysis. As Patton (2002) comments:

> Analysis programs speed up the processes of locating coded themes, grouping data together in categories, and comparing passages in transcripts or incidents from field notes. But the qualitative analyst doing content analysis must still decide

> what things go together to form a pattern, what constitutes a theme, what to name it, and what meanings to extract from case studies. (p. 442)

6.7.2 Analysing the questionnaires

Before entering data from the completed questionnaires, the data had to be screened to exclude unusable returns. Five student questionnaires fell into this category because they had obviously been filled in facetiously, using inappropriate or nonsensical language. Occasionally individual answers seemed improbable (eg students claiming to be Satanists) but in the absence of any additional evidence that they were not treating the task seriously the decision was taken to incorporate them. Otherwise, the researcher is in danger of excluding “surprising results” and, in the words of Gorard (2003) could be “on a slippery slope to falsifying your data or simply making convenient results up” (p. 31). In practice, such cases represented a very small proportion of the total returns.

Although the majority of the questionnaires were completed on paper, many of the RE teachers used a web link to complete the form electronically via Bristol Online Surveys (BOS) software. To facilitate analysis, the hard copy questionnaires (for both students and teachers) were also entered into the BOS software. The data were then exported into SPSS software for further analysis. Non-parametric statistical tests were used because the data were not normally distributed (Connolly, 2007). Since the two samples were independent, a Mann Whitney U test was applied when comparing the Science teachers with the RE teachers (nominal variables) on rating scales (ordinal variables). The two-tailed test was used because there was no prediction made about the direction of any difference. When the two groups of teachers were compared on nominal variables (eg yes/no), a chi-square test was used.

Open responses were explored using the grounded theory-based approach outlined above.

6.7.3 Analysing the interviews and focus groups

Each interview and discussion was transcribed in full as soon as possible after the fieldwork had taken place to optimise the fidelity of the record. As recommended by Patton (2002), I typed up all my own transcripts personally in an attempt to reduce error and to begin the process of becoming immersed in the data. This assisted in initial analysis of the data as the fieldwork progressed so that, in line with the grounded theory approach, adjustments could be made to the questions or to the sample if it seemed appropriate. As well as reading and re-reading the scripts, I listened repeatedly to the recordings, to fully appreciate the implications of delivery, intonation, interaction and context.

The focus groups represented a more complex interaction than the one-on-one of researcher and participant in the individual interviews, and the analysis reflected that complexity. There is some controversy over whether the individual or the group should be the unit of analysis in focus groups (Kidd & Parshall, 2000). Members of the focus group will interact with each other as well as with the researcher. The analysis needed to reflect this, but be flexible enough to recognise that some elements within the focus group (particularly the use of visual representation of the science/religion inter-relationship outlined in Section 6.4.5) involved a more individual response. The analysis was sensitive to the influence of the group on the individual as well as the individual on the group. It followed the philosophy of Kidd and Parshall in defining neither one as the unit of analysis but either one as the focus of analysis as appropriate to the context.

6.8 The role, identity and influence of the researcher

It is widely recognised that the identity and viewpoint of the researcher have a fundamental effect on the nature of the research that s/he undertakes. Feminist researchers in particular have argued that the researcher will inevitably have a relationship with the phenomenon he or she is studying (Willig, 2001). According to Denzin (1989) “value-free interpretive research is impossible” (p. 23). Rather than strive for an unattainable objectivity, researchers are encouraged to reflect on their own position and the effect this might have on their work, and to state it clearly.

The topic of this research meant that religious and ethnic identity were particularly crucial. Most participants were young people. Many had a Muslim or Christian perspective. Although I took whatever steps I could to present my own position as neutral, there were certain things that could not be disguised. I was clearly a white, middle class, Western woman. It was easy to infer my approximate age and educational level (most knew that the study was contributing towards my PhD submission). All these characteristics have been identified as influencing what an interviewee is prepared to reveal. According to Denscombe (2007), “[i]n particular, the *sex*, the *age* and the *ethnic origins* of the interviewer have a bearing on the amount of information people are willing to divulge and their honesty about what they reveal” (p. 184, emphasis in the original).

Whilst recognising that interviewer neutrality is unachievable, my aim was to minimise the effect of my identity when conducting the fieldwork. As a non-religious person, the issue of exhibiting outward signs of a particular faith (eg crucifix, headscarf) did not arise. I was never asked directly about my religious beliefs either by students or teachers, and I never volunteered the information. However, assumptions might have been made. For instance, the Muslim participants were primarily from a Bangladeshi background which, from my physical appearance, I clearly do not share. Almost certainly they assumed that I did not share their Islamic faith either. These factors could have influenced the interviews. Bhopal (2001) argues that racial identity affects the research process, and that her commonalities with the South Asian women in her own study made them more likely to participate and disclose their experiences. She quotes one of her informants, "*If it [the researcher] was a white woman, I don't think I would have first let her come into my house and I wouldn't speak to her about things to do with my private life. She just wouldn't understand, how can she? They are different to us*". However, in my research the impact may have been diminished by the school context, since the students are used to operating in an environment where the majority of the staff do not share their ethnic or cultural background.

In my dealings with the teachers there was an additional factor at play, and that was my own lack of teaching experience. There seems to be no consensus in the literature about whether or not this is a disadvantage. Particularly in the field of the ethnography of education there has been vigorous debate about 'insiders' and 'outsiders'. Smetherham's (1978) experiences in the field as an 'insider' suggest that his teaching colleagues were more willing to 'share private knowledge with one whom they see as personally and equally involved in their world' (p. 100), but they also developed new defence mechanisms. McNamara (1980) is deeply suspicious of classroom observations conducted by those outside the teaching profession, claiming they reveal 'the parochial and limited view of the outsider' (p. 114). Yet, as Hammersley (1981) points out, the concept of being an insider is severely limited as it assumes an unlikely homogeneity in the sample. In my own research, for instance, the discipline taught and the type of school would act as sources of heterogeneity. In summary, I conclude that in those cases where my professional background was known, lack of teaching experience was likely to have less significance than the ability to establish an easy rapport.

6.9 Ethical issues

The two main ethical considerations in this research were to ensure participants were able to provide informed consent and that their privacy was protected.

Informed consent is described by Diener and Crandall (1978) as the process in which "*individuals choose whether to participate … after being informed of facts that would be likely to influence their decision*" (p. 34). In the teacher survey, potential participants were told the purposes of the study by covering letter or email (see Appendix 1.4) or, in the case of mentors (Section 6.6.1), by scripted preamble from the meeting convenor.

With one exception (where the fieldwork had to be completed in a very short time frame), I made a preliminary visit to each case school. This allowed me to explain the project in detail and to respond to any questions. I discussed the issue of obtaining informed consent for the students: in practice, only School B sent letters to parents (see Appendix 1.6), the other schools opting to act *in loco parentis*. The students were also asked to give their individual consent. It was explained that the main purpose of the research was to explore teaching of life on earth.

The potential sensitivity about discussing religious beliefs made it particularly important to clarify that participation was voluntary and there was a right to withdraw at any time, or to decline to answer any specific questions. The research was carefully designed to respect rather than challenge an individual's beliefs. It sought factual information about student and teacher understanding and comments on the teaching of origin of life in science and RE, and was not intended to probe religious beliefs. Before starting the study, advice was taken from teachers and my own colleagues about likely sensitivities, with particular reference to student participation.

I gave all participants a guarantee that their contribution would remain confidential (ie that their views would not be publicly ascribed to them), that no real names would be used in the report and that individual schools would not be identified. Clearly I met the participants in the qualitative phases, so confidentiality (ie that nobody *else* would know what they said) was the most I could promise them. For the surveys, total anonymity was possible, although those teachers who were prepared to do so were asked to provide their contact details. The student questionnaire, completed on paper and with no request for names, allowed a high degree of anonymity. However, on those occasions where I was present when the questionnaire was filled in, it was clear that – despite encouragement to complete the task in isolation – some students discussed it with their neighbour(s). A downside was that a few students used the cloak of anonymity to furnish frivolous answers without fear of reprisals, and duplication within these suggested some respondent collusion.

7. Analysis 1: Teaching and learning about the origin of life

In this chapter, after a brief profile of the survey sample, a section is devoted to each of the four research questions. Consonant with the mixed methodology, analyses of different data sources are reported in an integrated fashion.

Before performing any statistical analyses, the teacher survey data was examined by eye. This showed no obvious differences by method of data collection (postal, online, mentor meetings etc). Consequently, the decision was taken to report on combined samples, comprising 55 Science teachers and 98 RE teachers. Incomplete questionnaires and responses from those who were not currently teaching the origin of life were excluded. Non-parametric statistical analyses were used because it could not be assumed that the data were normally distributed.

The postal and online proportion of the final teacher sample was self-selecting (Section 6.6.1) and the case schools were chosen to be representative of particular contexts (Section 6.6.2) thus restricting the reliability and generalisability of the findings. On the other hand, some triangulation across data types and sources (qualitative and quantitative, teachers and students) has been possible. The resulting picture is rich in detail as well as giving an indication of the prevalence of different positions.

Where verbatim quotations are cited in the following chapters they are labelled as either a teacher (T) or a student (S) utterance. They are further identified using the following coding scheme:

- Teacher survey: Science or RE sample and individual questionnaire ID (eg T/Sci/q75)
- Teacher interviews/focus group: Science or RE sample and case school (eg T/RE/A)
- Student survey: school and individual questionnaire ID (eg S/A/q9)
- Student pair or focus group: school and group or pair ID (eg S/C6)

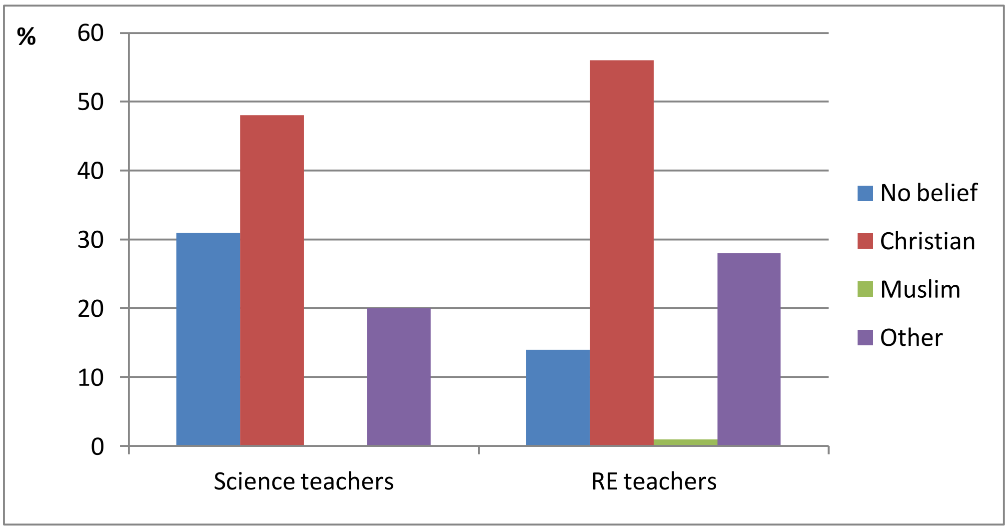
All case school participants are referred to by pseudonyms (the survey respondents are not named).

7.1 Sample composition

Roughly two-thirds of the teachers who returned their questionnaires were female (61% of Science teachers, 66% of RE) which is in line with national figures[5]. The majority had more than five years teaching experience (75% and 79% respectively). To reflect the national picture, 19% of the sampling frame consisted of faith schools[6]. Of the final sample, 14% of RE teachers and 25% of Science teachers were in faith schools (most of which were either Church of England or Catholic).

Asked about their religious beliefs, both sets of teachers (48% of Science teachers and 56% of RE teachers) were most likely to define themselves as Christian (Figure 7.1). Based on these small sub-samples, when asked to rate their strength of belief on a five-point scale, the figures suggested that Christian RE teachers had a stronger faith than their Science counterparts (63% and 50% respectively having a very strong or strong faith). Science teachers were more than twice as likely as RE teachers to say they had no belief (31% versus 14%). A larger proportion of RE teachers said they were "not sure" about their religious beliefs (included in Figure 7.1 as "other").

Figure 7.1: Religious beliefs of teachers



There were 41 student survey returns from School A, 30 from School B and 138 from School D, making a total of 209. The samples in Schools A and D were split fairly equally by gender. School B was a single sex school so all respondents were female. In terms of religious faith, the dominant group at School A was Christian (73%) and at School B it was

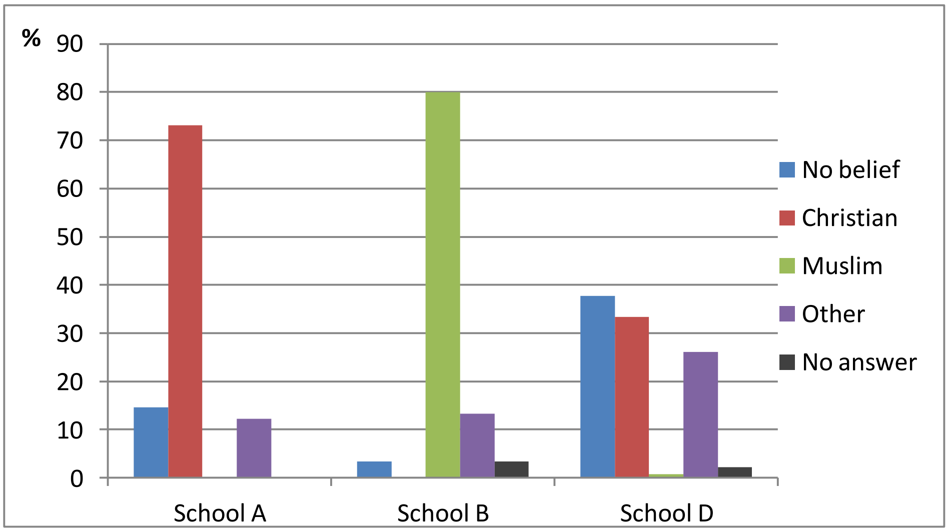
[5] 62% of registered secondary school teachers are female (GTC Annual Digest of Statistics 2010-11)

[6] Most recent figures show 17% of secondary schools have a religious character (DfE: Schools, Pupils and their Characteristics, January 2011)

Muslim (80%) (Figure 7.2). Although the largest group at School D had no religious belief (38%), almost as many defined themselves as Christian (33%) and there were small numbers professing other beliefs (eg Buddhism), a few agnostics and 9% who were "not sure" (combined as "other" in Figure 7.2).

Across the total sample, 77 students described themselves as Christian, 26 as Muslim and 59 as having no belief. Muslim students were more than twice as likely as Christian ones to describe their belief as very strong or strong. The Christians at the faith school (School A) expressed a similar strength of belief to those at School D.

Figure 7.2: Religious beliefs of students

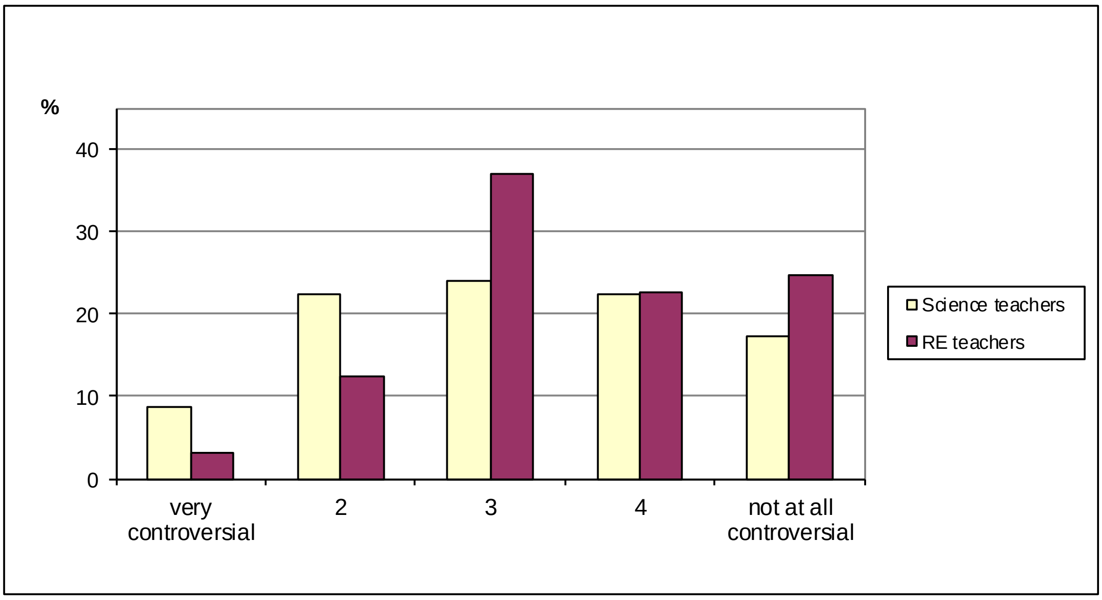


7.2 What are Science and RE teachers' opinions about teaching scientific and religious explanations of the origin of life?

7.2.1 Teacher perception of topic as controversial

There was a spread of opinion among the surveyed teachers about whether the origin of life constituted a controversial topic (Figure 7.3 overleaf). Far more RE teachers opted for the non-controversial end of the scale (48%) than the controversial end (15%). The picture was more mixed among the Science teachers with almost a third thinking it controversial (31%) and slightly more that it was not (39%). Comparing the two, Science teachers were twice as likely as RE teachers to rate it towards the "very controversial" end of the scale, although the difference failed to reach statistical significance (p = .129, U = 2241, Z = 1.517).

Figure 7.3: How controversial do you personally think this topic (origin of life) is? (Teachers)



This pattern was reflected in lived experience, where Science teachers were significantly more likely to have found it controversial in their classroom: 56% compared with just 34% of RE teachers (*p* = .009, chi-square (1, N=151) = 6.923). Teachers were asked to provide more detail about how it had been controversial, and their answers were analysed using a grounded theory approach. Table 7.1 shows the type of issues that arose.

For both Science and RE teachers, the main reasons for the origin of life proving controversial were classified either as "student perspectives" or "student interactions". Table 7.1 shows how these categories emerged from the initial codes, and gives more detailed descriptions of how the codes were constituted.

For Science teachers, the problematic student perspectives were almost exclusively resistance to the scientific explanation from students who took their religious teachings literally (ie "literalism" code):

> *Muslim and Christian beliefs.* T/Sci/q23

> *Evangelical teaching re "truth" of Old Testament.* T/Sci/q4

Whether there was a feeling of frustration or intolerance behind Science teachers' attitudes was unclear, the explicit dismissiveness of this comment being rare:

> *Ignorance of student belive [sic] and faith in utter nonsense.* T/Sci/q7

RE teachers had also encountered such standpoints:

> *Pupils (evangelical Christians) ask "so are we really descendants of monkeys?". "Evolution cannot be proved so why should I believe it?"* T/RE/q110

Table 7.1: Coding of origin of life being controversial

Category	*Code*	*Description*
Student perspectives	literalism	faith position of student: find it incompatible with their literalist view eg Jehovah's Witness
	scientism	students dismiss religion; privilege scientific over religious knowledge
	science/religion in opposition	students perceive science and religion as incompatible
Student interaction	range of views	teacher has to deal with religious literalists, religious liberals and/or those who dismiss faith viewpoints in same class
	stimulates debate	topic provokes lively debate; teacher welcomes it; seen as positive
	debating positions	description of what is debated
	maintaining respect	teachers have to ensure students respect each other's views
Presentational issues	theory not fact	teacher being sensitive to evolution as theory not fact
External factors	third party antagonism	opposition from parents, local religious groups etc

However, RE teachers were equally likely to report issues with students who did not want to engage with the religious arguments at all and sometimes refused to treat religious beliefs seriously or respectfully because they were so firmly attached to the scientific viewpoint:

> *Majority of students believe that Science is always right therefore to suggest that there is another explanation often controversial.* T/RE/q29

Behind the category of student interaction, where interplay between different perspectives sparked controversy, lay a mix of positive and negative teacher experiences. A teacher could find the polarised views challenging and demanding of careful classroom management:

> *Some students are brought up with a belief in the literal interpretation of Genesis, others see Genesis as disproved - I need to ensure both groups are respectful of others' views.* T/RE/q90

In contrast, several teachers (both RE and Science) explicitly stated that the controversy was something they welcomed or sought. This was the case where it led to lively argumentation and debate:

> *Can sometimes cause heated debate between pupils of different faiths but as a teacher of this topic, I find this interesting.* T/RE/q82

Controversial in a good way to provoke listening to different views; justification of ideas etc. T/Sci/q48

All good discussions should be 'controversial'. T/RE/q20

In a similar vein, teachers in the case schools wanted to create an atmosphere where students felt comfortable expressing their views, but they were concerned that this was not always achieved. To some extent, this was considered to be a function of age:

Rick: *... at KS5 ... students are maybe happier about expressing their ideas, slightly more confident about it. In a KS4 class, not all students might articulate their ideas even in written work. If they feel - I don't know, I just feel that sometimes you don't necessarily get the same openness there.* T/RE/A

At a much lower level, some parents or religious communities had objected to evolution being taught and there had also been issues with it being presented as an incontrovertible fact rather than a theory.

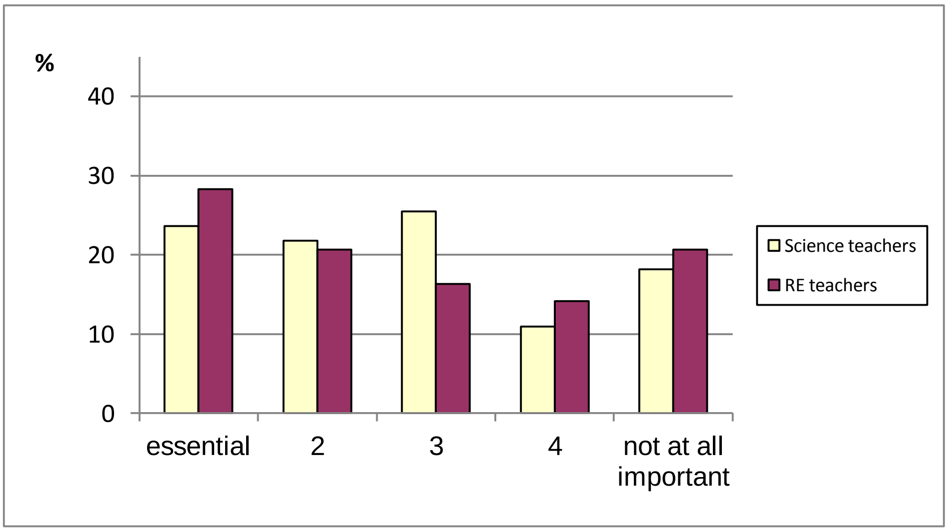
The reasons teachers gave for the topic being controversial find close parallels in three of the criteria that Levinson (2006) proposes as definitive of controversial issues (Section 5.1.4), ie: people start from different premises and hold conflicting positions (student perspective category); considerable numbers of groups or individuals are involved ("range of views" code in student interaction category); and the issue cannot be decided by the evidence (presentational issues).

When case school teachers were asked whether the topic provoked controversy in the staffroom, the answer was no, with two exceptions. Firstly, there was a member of Science staff at school A who did not accept evolution above the level of the species. As head of Science, Phil said he advised the teacher that "*the thinking is that species have developed by evolution across – evolution to make new species and so on*". Whether the teacher taught speciation despite his personal views was unclear. The second example was in the Science department at School B, where Laura described the staff as including "*people from the community, Islamic Science teachers [...] other people come from different standpoints. So we do have some good discussions actually. There's one [...] he's always googling things about the latest dreadful things on the intelligent design websites and things like that. But again, you do notice some people just go quiet, they don't want to – it's just too close to home.*" Because the Islamic teachers did not volunteer to take part in the research, and Laura had not observed their lessons on the origin of the universe or evolutionary theory, it was not possible to know how they dealt with it in class.

7.2.2 Views about covering religious beliefs in science lessons

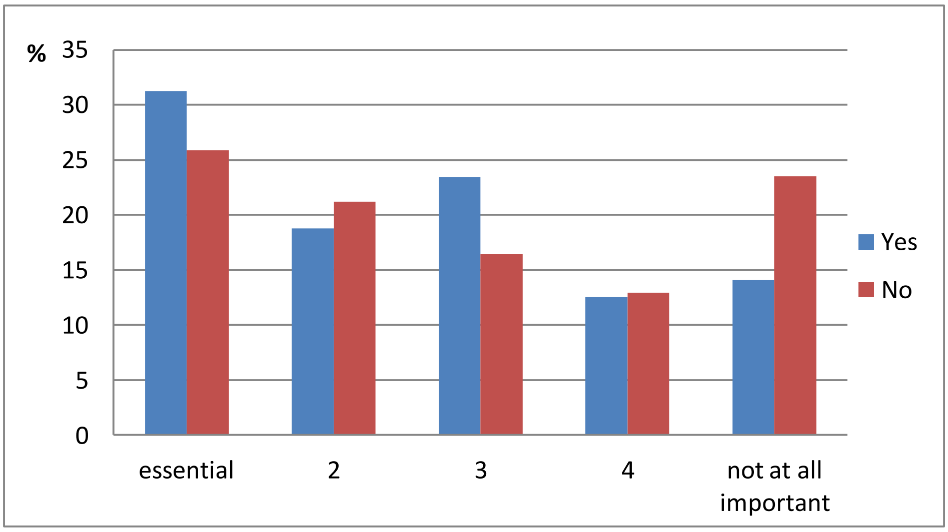
Around a quarter of both Science and RE teachers (24% and 28% respectively) considered it "essential" to teach religious beliefs about the origin of life in the science classroom (Figure 7.4). Slightly fewer thought it was not important, with about a fifth in each case opting for “not at all important” (18% Science, 21% RE). There was a spread of opinion between the two extremes. Although the skew was towards the “important” end of the range in both cases, Science teachers were more likely to opt for the midpoint and RE teachers to be at either extreme. There was, however, no statistically significant difference between the samples (p = .949, U = 2597, Z = 0.064).

Figure 7.4: How important is it to cover religious beliefs about the origin of life in the science classroom? (Teachers)



Teachers who had never experienced the topic as controversial in the classroom were more likely than those who had to think that covering religious beliefs in science was “not at all important” (Figure 7.5 overleaf) although this did not reach statistical significance. There was also a slight tendency for the converse – that those who had experienced it as controversial thought such inclusion “essential” (p = .187, U = 2384, Z = 1.321).

Figure 7.5: Importance of covering religious beliefs in science by whether experienced topic as controversial (Teachers)



By far the main reason why RE teachers thought religious explanations should be included in science lessons was to provide information on all perspectives, often described as “balance”:

> *Students need to have a balanced idea of the origins and purpose of life on earth.* T/RE/q75

> *To give a balanced view and make sure students understand that there are other points of view.* T/RE/q71

Sometimes this standpoint about ensuring balance was justified as exposing students to an epistemological debate around the relative validity or questionability of religious and scientific explanations:

> *They offer a suitable counter-balance to theories covered in science. It encourages students to be truly scientific and explore all theories rather than the 'absolute truth' presented by some science teachers.* T/RE/q52

> *Science should touch on the subject - because the Big Bang and Evolution are theories [underlined] not fact and must show balance between science and faith (like we do in RE).* T/RE/q101

Another aspect that RE teachers perceived to be important was showing the link between science and religion – several comments were about demonstrating that the two can comfortably co-exist:

> *I feel it is important that pupils have an awareness of religious viewpoint in light of scientific discovery and can understand how religions try to reconcile religious beliefs with scientific evidence.* T/RE/q58

> *Pupils need to understand where and how the two subjects are compatible.*
>
> T/RE/q60

> *Religion and Science do not have to be in conflict. They aim to understand how and why we are here. Many scientists are religious.* T/RE/q16

Many Science teachers also thought it was important to provide students with a range of explanations. However, there was often a caveat to emphasise that the teachers made clear which ones were not scientific, and comments about making such diversions short:

> *A balanced view should include a brief look at religious beliefs.* T/Sci/q59
>
> *I feel that all ideas should be put before students - make up own mind - but must use certain ideas for exams.* T/Sci/q60
>
> *Mention that other ways of explaining how life began are around - not that are scientific [underlined] statements eg ID.* T/Sci/q19

Science teachers were also motivated to include the religious aspect to enhance student understanding of the context within which Darwin's theory was developed and slowly accepted, thus fulfilling some of the requirements of the How Science Works aspect of the curriculum:

> *Pupils want to discuss it. It makes for a good opportunity to discuss "How science works".* T/Sci/q32
>
> *It sets the scene for why Darwin's theory wasn't accepted at the time despite evidence available.* T/Sci/q53

The Science department at School D seemed to reflect this angle in the way they said they would cover challenges to evolution, by emphasising that it was the best scientific explanation currently available rather than engaging directly in a discussion of its validity compared with a literalist religious interpretation.

Another aspect of understanding that Science teachers in the survey wanted to encourage related to tolerating different viewpoints:

> *Essential to explain that others do have different beliefs and are allowed [double underlined] to!* T/Sci/q56

Finally, some Science teachers wrote that they worked in a faith school (mostly specified as "Christian" or "Catholic"). Often, they felt this was self-explanatory as an answer and gave no more detail, so the following quote is unusual in its richness:

> *Being a Christian myself and teaching in a Catholic school I feel that that aspect of basic Christian belief should also be part of the argument. I feel strongly so because just to tell pupils that organic matter evolved from inorganic source is not sustainable. The popular question is 'Does it or can it happen today?'* T/Sci/q8

For all those teachers, regardless of subject, who did not think it important to cover religious beliefs about the origin of life in Science, the main reason revolved around the nature of religious and scientific truths being very different as illustrated by this questionnaire extract:

> *Religious beliefs are ... beliefs and not scientific - the science classroom is for those ideas which can be objectively tested and demonstrated - that is the nature of science ... If we taught non-scientific ideas in science we would have to include a full range of weird and wacky ideas! I always teach some basic science in the RE classroom and refer students to science teachers if they have complicated*

> *science questions I am not sure about. If we are talking creationism in this question, let [sic] be honest and recognise it is not science!! The RE classroom is by its nature broader than the science lab and can consider a range of ideas which are not scientific, but faith based, as well as looking at broad scientific ideas.*
> T/RE/q55

Several RE teachers felt that RE was the more appropriate place to cover such beliefs because the teachers had the relevant skills whereas Science teachers had not been trained to do so with sensitivity. The latter point was one that concerned Dean, the RE teacher at School D, who felt that casual treatment of religious objections could imply an inevitable superiority of Science:

> Dean: *RE teachers have training in teaching controversial issues, I'm not sure whether Science teachers have that particular training [...] I dunno, maybe Science teachers would be, if they had to teach creationism, would treat it not as seriously as say we would treat that in RE [...] the pupils would think that the science part is always right.* T/RE/D

Science teachers who thought that religious belief should not feature in their lessons tended to justify their opinion by defining it as an RE issue which should be confined to that area of the curriculum:

> *1 It is not science; 2 Pupils cover it in RE (compulsory to end of KS4); 3 I am not qualified to teach RE, I am qualified to teach Biology.* T/Sci/q28

As already discussed there was also an argument that it was not going to be key for student exams:

> Isobel: *I'd allow discussion if religious views were raised, I kept them brief, gave the 'for the sake of the exam...' lecture and did nothing to encourage it further.*
> T/Sci/C

Science teachers in the focus group at School D described themselves as "*not a very religious department*", but in the lesson observation the teacher (who was not present at the focus group) contextualised evolution through a discussion of how she had reconciled it with her own Christian faith. It was unclear whether this was her usual approach or whether it was affected by her knowledge of my interests. The staffroom context seemed to have a considerable bearing on how teachers might handle the issue. Isobel said that most other Science staff at School C were quite deeply religious, leading to a clash of views over what should be taught and making her "*quite strongly opinionated in my own non-religious view*". She left the school after the fieldwork period and her new colleagues did not have a religious drive, making Isobel much more relaxed about the topic in the classroom: "*so I am quite happy to discuss religious views with pupils in science, and compare them with evolution, big bang etc*". Indeed, she had just written a Year 7 scheme of work that covered different beliefs before proceeding to the scientific explanations. She expressed amazement at how quickly she had altered in response to her changed social environment.

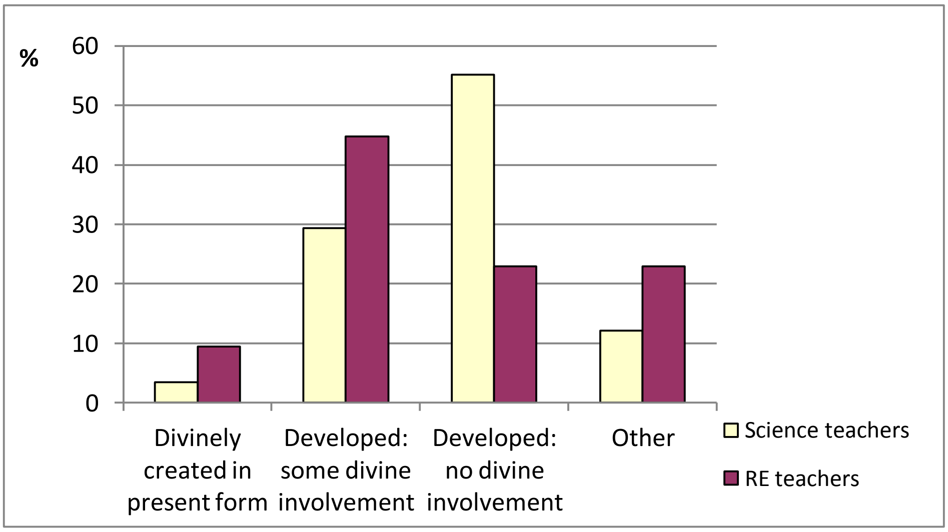
7.2.3 Teacher views on the origin of life

Students were more likely to categorise those teaching RE rather than Science as having beliefs about divine involvement, and this perception was supported by findings from the teacher survey. The vast majority of teachers agreed that humans have developed over millions of years (Figure 7.6).

Amongst RE teachers, the preferred option was evolution with some supernatural involvement (45%). Almost a quarter (23%) accepted evolution without any divine involvement. Another 23% wrote in their own explanations. These covered a range of responses, including those who could not choose between two of the options and those who were unsure ("*I am still trying to decide with my pupils!*" T/RE/q26).

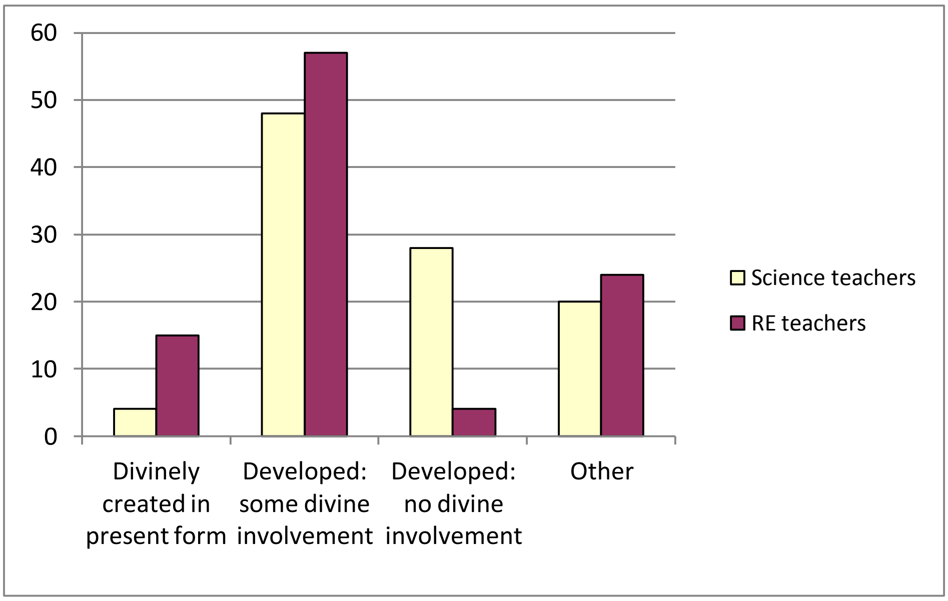
Science teachers were more inclined to opt for long-term development with no divine involvement (55%), although 29% thought a divine being had played some part in the process. Compared with RE teachers for these two answer categories, the difference in response pattern was significant (p<.001, chi-square (1, N=120) = 12.87). There were 12% of Science teachers who came up with alternative answers – again representing a number of views, mainly those who were uncertain or wanted to make clear that opinions other than their own were acceptable. In total, nine RE and two Science teachers opted for the explanation that 'human beings were created by a divine being pretty much in their present form'. Although (as already discussed) it is not possible to generalise from the sample, this does mean that at least some students are receiving instruction on evolutionary theory from Science teachers who do not personally find it an acceptable account of how human life developed.

Figure 7.6: Teachers' opinions about origin of human life



It is possible that variables other than the difference between being a Science and an RE teacher had a bearing on the pattern shown in Figure 7.6. One obvious candidate is the religious background of the teachers. If the question about origin of human life is analysed by Christian belief (the only religious sub-sample large enough to act as a variable), a lower proportion of this group opt for a naturalistic explanation. However, there is still a clear difference between the two sets of teachers (Figure 7.7). Science teachers who are Christian are much less likely than their RE counterparts to assert that human life has evolved with divine intervention or humans were created by God, and more likely to opt for evolution without any divine involvement (p = .001, chi-square (1, N=60) = 11.825). This suggests that Science teachers were more likely to deny divine involvement regardless of their faith, although it should be noted that RE teachers rated the strength of their faith more highly than Science teachers did (p = .013, U = 189, Z = 2.48).

Figure 7.7: Christian teachers' opinions about origin of human life



Responses from the general public to a similar question in recent UK and GB surveys were described in Section 4.1.1. As has already been discussed, because the surveys vary in their wording, any comparisons are indicative only. However, it is noteworthy that RE teachers fell further outside the range of responses from the general public surveys than did Science teachers (Table 7.2). They were less likely to opt for one of the given categories at all, perhaps because they had considered it more deeply and had more complex responses as a result. A higher proportion of them than the general public thought there had been something equating to theistic evolution, whilst fewer opted for evolution without supernatural involvement. Science teachers, in contrast, were slightly more inclined than the general population to accept a solely naturalistic explanation. Both sets of teachers were comparatively unlikely to believe in divine creation of species without evolution. This may be at least partly explained by the greater prevalence of this position among over-65s, lower socio-economic groups and those with less education

(Alfano, 2005; British Council, 2009; Lawes, 2009) - demographic groups in which teachers are scarce or absent.

Table 7.2: Survey responses: opinion about how human beings came into being

	GB/UK range[†] %	Science teachers %	RE teachers %
divinely created in present form	16-22	3	9
developed: some divine involvement	17-39	29	45
developed: no divine involvement	37-53	55	23
other	13	12	23

[†] See Table 4.1 for detail

7.3 What are students' opinions about the scientific and religious explanations of the origin of life?

In the survey, students were asked "How do you think life on earth came into being?". Despite that wording, many students interpreted the question as asking about the origin of the universe, resulting in several mentions of the big bang. The same confusion was apparent with some RE teachers (Section 7.4.1), perhaps reflecting the juxtaposition of the two in the RE curriculum (Section 3.3.2) and in the main Judaeo-Christian texts (Section 2.1), where creation of the earth tends to be presented almost seamlessly with the creation of living things. Only a minority of students seemed able to clearly distinguish between the two, even though they are treated entirely separately in the Science curriculum (Section 3.3.1). They constitute part of different modules that may be separated by several months or even straddle two academic years.

The pattern of response varied by school, and this in turn was influenced by the religious beliefs of the students. Table 7.3 (overleaf) summarises the answers by school. The verbatim responses have been coded into broad categories to clearly illustrate the proportion of students giving a religious explanation only, a scientific explanation only or mentioning both.

Table 7.3: How life on earth came into being (student survey) by school

	School A	School B	School D
	41 %	30 %	138 %
Science only	39	7	61
God only	15	80	14
God/science mix	37	0	10
Other	5	3	4
Unsure/DK	0	10	8
Not answered	5	0	2

School A students, almost three-quarters of whom described themselves as Christian, gave a wide range of responses most of which incorporated some scientific element (the big bang, evolution, or both). Over half of these specified some role for a divine being (for instance, God causing the big bang or acting subsequently to create life or instigate evolution):

> *Big Bang made earth and bacteria (or something else) grew to form animals and plants and they adapted to their habitat.* S/A/q8

> *I believe in that god and science (big bang) helped create the earth. God = scientist and earth was his experiment*. S/A/q20

This mix was also reflected in the focus groups, including the interplay of science and religion:

> Michelle: *I think the big bang, the world was made by the big bang but God created all the stuff that was in it, so if the big bang didn't happen then God obviously wouldn't be able to make the stuff that was in it.* S/A2

A mix of views was also represented in School D and although the majority gave a purely scientific explanation, a sizeable minority thought God had created life, or was not sure if God was involved, or opted for a blend of scientific and religious reasoning. As with School A, this pattern was repeated in the focus groups.

In School B, with its predominance of Muslim students, only two out of 30 thought that life had a purely scientific origin. Most of the remainder said God had created it. Interestingly, although several students at School B said in the focus groups that they believed in a big bang caused by God, not a single one of the School B questionnaires had this as an explanation. However, the big bang was the most common alternative explanation they were aware of, showing it was not lack of knowledge that had caused the omission. This raises the issue of whether a divinely-initiated big bang is a convenient stance adopted by these students to pacify teachers – and researchers – when they are challenged on the issue. Perhaps the absence of the scientific dimension in the anonymous survey was a more realistic reflection of their viewpoints:

> *God created the Earth. He created all living things, and every aspect that is on the Earth*. S/B/q27

> Sumaya: *the whole big bang theory it could be possible but the reason behind the big bang theory would be because God wanted the big bang to happen and he caused the big bang theory.* S/B1

Students were then asked to indicate their position specifically on the origin of human life, using the list of three statements described in Section 6.4.3. The answers have been analysed by faith and by school. Figure 7.8 shows that most of those with no religious belief thought humans had developed over millions of years with no divine involvement. There was a wider spread of views among Christians, although over half thought there had been gradual development with some involvement from God. Just over one in ten thought God was not involved in the process, and roughly the same proportion thought God had created humans pretty much in their current form. This latter position was deliberately not defined by timescales, so could cover adherents of various viewpoints (eg any of those Scott (2009) has defined on her spectrum as young-earth, gap, day-age or progressive creationism). Creation of humans by God in their present form was the explanation overwhelmingly adopted by Muslim students (23 out of 26).

Figure 7.8: Students' opinions about origin of human life by religious belief

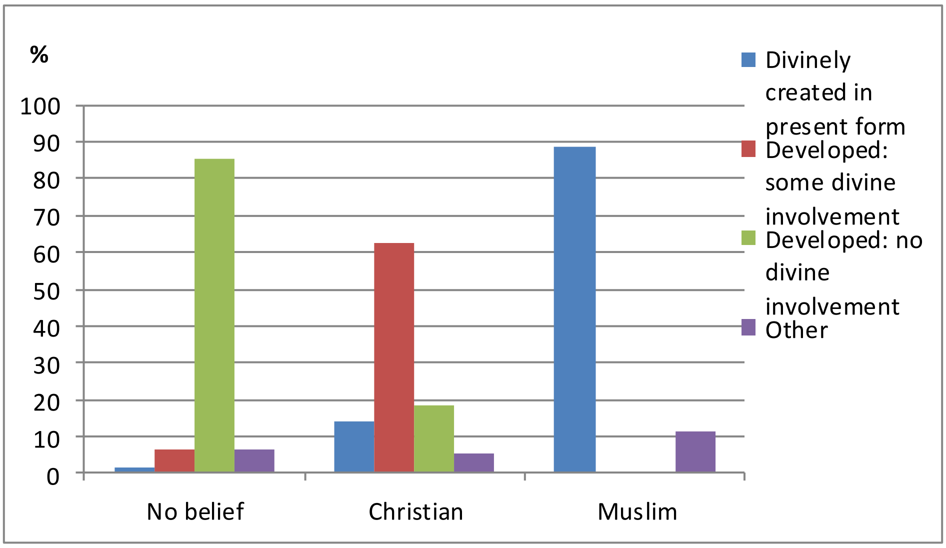


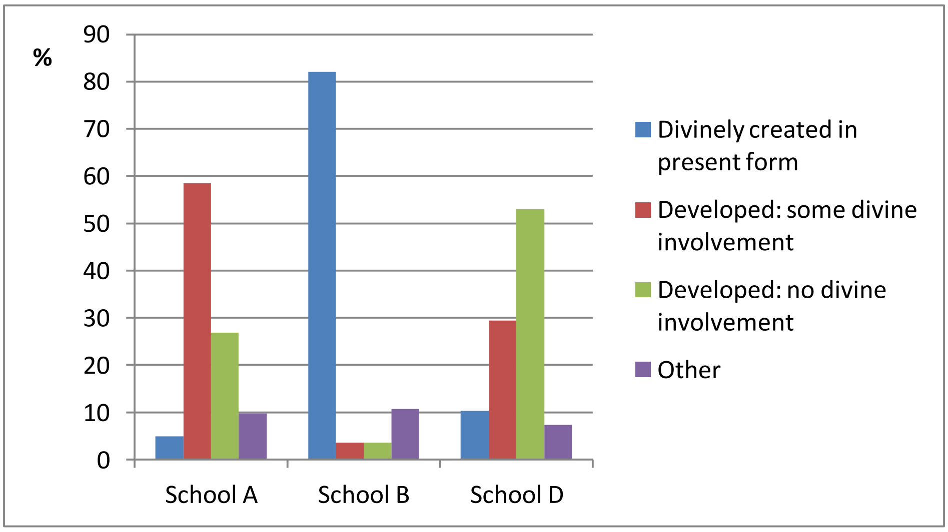
Figure 7.9 displays data from the same question by school attended. It shows that there is the greatest homogeneity in School B, with the high proportion believing humans were created by God in their current form reflecting the Muslim background of most students. However, Section 9.2 will propose there was more attitudinal variation behind this than these figures might imply.

A majority of those attending School A declared themselves to be Christian, but it was the school with the lowest percentage of those adopting the "special creation" position – gradual evolution with some input from God was the most popular response, and one in four thought God had not been involved in this process at all.

The picture was most mixed at School D – the school chosen to represent no specific faith background. Although around half opted for the position of evolution without any divine involvement, over a quarter thought God had been involved and one in ten (ie more than in the Christian faith school) favoured the "special creation" explanation. This was not something predicted by either their Science or RE staff:

> Dean: *I wouldn't say we have any creationists in this school, but I think some see their faith as something that needs to be explored and science sometimes gives them a challenge to that.* T/RE/D

Figure 7.9: Students' opinions about origin of human life by school



There was some evidence of views changing over time (as this question was added during the fieldwork, there is only information for Schools A and D). Some students made the point that they had not come across the scientific explanations for the origin of life and the universe until secondary school, whereas religious accounts had often been introduced at primary school or – if they were from a religious background – at home or a place of worship:

> Tamsin: *[...] you first get told it was made by God, that's what they teach in primary school I think. And God made it in 7 days. And then when you go on to do science*

> *in secondary school you learn about big bang and all that kind of stuff [...] when you were primary school age that's when you're taking in information and you believe what you hear and don't actually have your own opinions and thoughts and stuff [...]. And when you get older it's, this is what happened but here's the proof [...]* S/D2

Although several focus group students perceived the issue as non-controversial – both for themselves personally and society at large – others were aware that it could cause difficulties although these did not always reach the surface. They recognised that a critical mass was usually needed before anyone was likely to contest what was being taught in class, regardless of the nature of the school. Sometimes this was because of fear of fellow students' reaction, other times it was in deference to the teacher's knowledge:

> Leila: *But there's people who are so ignorant that in classes that kind of take away people's […]*
>
> Researcher: *When you say take away people's ...?*
>
> Leila: *Put them down*
>
> Tamsin: *Pressure*
>
> Leila: *It's like they're wrong but it's what they believe*
>
> Kat: *Cos if the majority of the class believe in that you're not going to be "hang on a minute, I believe in this" because you get everyone else challenging you*
>
> Tamsin: *It's little groups in each class that challen*ge. S/D2

> Researcher*: ... has anyone ever, for instance, in science challenged the scientific explanation in the classroom?*
>
> Samuel: *No, actually, when we were doing it everyone went ok, that's the science part behind it. Maybe some people did think it was God's hand but didn't bring it up because Science teachers generally know what they're on about I suppose.* S/A1

Such guarded behaviour may have grave ramifications for classroom dialogue. According to Levinson (2006), students failing to be open about their opinions, for whatever reason, jeopardises the ability to hold successful discussions of controversial issues.

More than one student, however, made the point that – even if it was controversial – the significance of the issue needed to be kept in perspective:

> Amira: *... everyone's got different views on how they think the universe was created so yeah, it is controversial, but I don't think everyone has arguments over tea or something (laughter).* S/B4

7.4 What are the differences, if any, between how the origin of life is dealt with in Science and RE classrooms?

7.4.1 Content of coverage

As would be expected from the curriculum (Section 3.3.1), every Science teacher in the survey claimed to cover Darwin's theory of evolution in their lessons about the origin of life. The vast majority (85%) mentioned at least one other scientific explanation: in 20 out of the 25 cases where detail was given, this was Lamarckian theory (although it should be noted that Lamarck was the example given in the questionnaire, which may have boosted this proportion). Perhaps more surprisingly, 80% of the Science teachers said they usually mentioned religious beliefs about creation. Although encouraged to do so, few wrote in further particulars of what this comprised. It was more likely to be addressed from a Christian angle (five mentions compared with just one for Muslim beliefs). Three teachers referred to creationism and three to Intelligent Design (because of overlap, this equated to five teachers in all), and three more vaguely to "creation". The wording of this question ("mention") could of course encompass a wide variety of levels of coverage, from the most superficial namecheck to an in-depth exploration.

In the interviews, Science teachers described three main ways of incorporating the religious dimension:

- as a historical example of an element of "how science works", giving students an insight into a socio-cultural issue faced by Darwin when publishing his theory and getting it accepted
- as reassurance for religious students that the spiritual and scientific can be complementary (particularly School A)
- as a value system for students to reflect upon to explore what effect it may have on the way they approach Science (mainly in School B)

Again in line with expectations, all the RE teachers in the survey covered religious beliefs about the origin of life. Where the requested detail was supplied, 54 of the teachers referred to beliefs from the Christian tradition, well ahead of Islamic (22) or Hindi (19) explanations. Most RE teachers (91%) said they incorporated Darwin's theory of evolution into their teaching, and 43% covered other scientific explanations. Many of these "other" explanations were technically about the origin of the universe rather than life itself as they mainly concerned the big bang (24 mentions). A handful of teachers covered other cosmological theories, such as steady state. Interestingly, only one RE teacher specified Intelligent Design and just three creationism (as opposed to creation stories or myths, which were listed by 13 teachers).

In the interviews, RE teachers said they used the example of scientific theories to illustrate the type of challenges raised in the context of arguments for and against belief in God. They described the incorporation of scientific explanations into their lessons as broadening the perspective when teaching design arguments for the existence of God (ie that the universe shows evidence of design therefore there must be a designer).

The students in the focus groups tended to report the coverage of origins being more comprehensive in RE than in Science, with content including theories of evolution and the big bang as well as religious explanations. Some contrasted this with their experience lower down the school or at primary school, when they had only learnt about the religious perspective (either the Judaeo-Christian creation angle, or various creation stories across a number of faith traditions).

Only rarely did students recall that Science lessons had dealt with anything other than scientific theories. The exception was in School C, but this seemed to be entirely a result of the religious beliefs of one student, Rosie, a vociferous Mormon (Section 9.3.2):

> Lisa: *There's long discussions about – Rosie and God and dinosaurs and things like that – she's very religious I think.* S/C3

It is ironic that Isobel, the Science teacher at School C, considered she had kept any discussion of religious views brief (Section 7.2.2).

In all the lesson observations there was some cross-curricular content. However, it was unclear how much this was influenced by teachers, aware of the focus of the research study, trying to provide a "relevant" experience which therefore became an atypical one. At School B, timing of the curricular cycle meant it was only possible to observe a Science lesson on the origin of the universe rather than of life. Students were put into small groups and considered either scientific or religious explanations, with the emphasis being on identifying the evidence for each position. Resources used included Islamic websites and copies of the Qur'an. Laura, the teacher, explained to the students why their use of the word "believe" was inappropriate in a science context and linked this to an instruction to focus instead on evidence. She steered some of her students to the conclusion that science and religion could not be directly compared because the evidence base was different. As one student expressed it, "*One's not better because they're not the same*". However, it was unclear how widely or sincerely this perception had been accepted.

The Science class observed at School D (the school with a non-faith catchment) covered evolution. The teacher, Alice, described the "theory" that the earth and all living things had been created by God. She set this in a personal context, explaining that her grandmother believes it to be literally true but, although also a Catholic, she herself had decided to interpret the Bible more loosely. Of the four lessons observed, this was the only example of a teacher introducing a self-revelatory perspective. She proceeded to describe the alternative theories of Darwin and Lamarck. Alice assured me that this was her usual approach to the topic – if it was, it would be not be typical of the science department as a whole, which characterised itself in the focus group as non-religious.

The two RE lessons in School D were taken by Dean, and they shared a similar content and format (albeit tailored to low and high ability sets). The learning objectives were to understand the religious creation stories and to compare these stories with scientific ideas. During discussions about the origin of the planet, the teacher was careful to distinguish the origin of the universe from the origin of life. Students went on to consider the two together when exploring the evidentiary basis for a number of statements (about teleology, the big bang, evolution etc) and when creating a cartoon strip representing the biblical story of creation.

That the majority of Science teachers claimed to mention religious beliefs to some extent whilst teaching the origin of life suggests that they did not exclusively follow what Cobern and Loving (2001) referred to as the pluralist approach to teaching science. Pluralism restricts school science to a definitive area of knowledge and excludes “art, history, economics, religion, and many other domains”. In Schools A and B there was some evidence that the intended pedagogy was closer to the multicultural model outlined by Stanley and Brickhouse (2001). Scientific and religious explanations were presented as equally valid alternatives, with the emphasis being on how the two could co-exist (Section 5.2.2).

Students’ perceptions of the pedagogical and philosophical approaches of Science and RE are discussed in more detail in Chapter 8.

7.4.2 Confidence in teaching alternative perspectives

Whereas over two-thirds of the RE teachers (71%) expressed confidence in covering scientific theories on the origin of life in their lessons (Figure 7.10), less than half (44%) of the Science teachers felt confident about covering the corresponding religious beliefs in their classrooms (p = .002, U = 1866, Z = 3.035). This low figure needs to be set in the context that 80% say they mention the religious explanations in their science teaching. Some teachers annotated their questionnaires to indicate that they would be comfortable talking about Christian beliefs, but felt insufficiently knowledgeable to tackle other religious perspectives.

It is questionable whether the RE teachers were always justified in their confidence in handling the scientific theories (for instance, as has been shown, there was some confusion between the origins of the universe and of life). As Head of RE, Rick was conscious that adequate knowledge of science was necessary for him to tackle the topic in an inter-disciplinary manner, and that the corollary would hold true for his colleagues in the Science department:

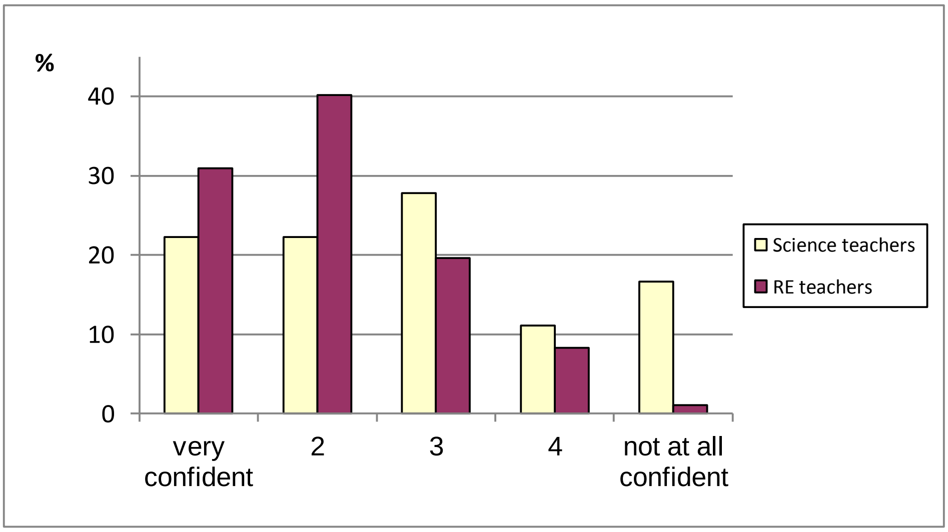
> Rick: *... if we say that when an RE lesson is dealing with a question of how the universe came to exist or a religious explanation for the existence of the universe, then science will come up [...] And in order to discuss that I suppose there needs to be a level of understanding of the scientific theories and I suppose if an RE teacher's going to talk about them they have to understand them themselves to be able to do that in any meaningful way. And I suppose then the same could be true of Science [...] if Science is expected to talk about, or to respond to a question of the alternative explanations for the origins of the universe, then there needs to be some level of competency around the ways in which different people would respond to that question.* T/RE/A

At School B, Rachel (the Head of RE) admitted that they had embarked on a Year 9 science and religion course without realising how challenging it would be to introduce students to the big bang theory before they had broached it in Science:

> Rachel: *...we found ourselves as religious studies teachers trying to teach the big bang theory and hadn't anticipated first of all how hard that was - because it's something people talk about casually don't they, oh big bang theory, you know how it happens, don't you? Well, no, we don't know how it happens actually and then when you try and explain it to 13 year olds we realised what an enormous thing we'd bitten off.* T/RE/B

Figure 7.10: How confident do you feel about covering scientific theories about the origin of life in the RE/RS classroom†? OR How confident do you feel about covering religious beliefs about the origin of life in the science classroom*?

(wording for *Science teachers; †RE teachers)



7.4.3 Amount of inter-departmental collaboration

Although most RE teachers were alluding to scientific theories about the origin of life in their lessons, and most Science teachers were mentioning religious beliefs, this was against a backdrop of a widespread lack of collaboration between the two departments. 62% of the Science teachers and 43% of the RE teachers said there was "none at all" with only four teachers in total (all RE) claiming there was “a lot”. There was no evidence of a difference for faith schools (albeit based on a sample of only 17).

The case schools were unusual in this regard, because Schools A and B did have some relationship between Science and RE – and in both instances these were founded to an extent on personal friendships between the heads of department. The joint working was demonstrated through informal interaction in School A, with Phil being invited to speak at an extra-curricular RE club, and Rick keeping abreast of scientific developments through casual conversations with Science staff. The association was attributed partly to being in the environment of a faith school. A barrier to increased closeness of working was simply finding time to set anything up:

> Rick: *We try to do that, we try to do stuff, maybe it’s not as much as we would like maybe, but that’s purely down to the reality of day to day teaching and busy-ness rather than anything else. I’m certain that, if I went to the science department and said can someone come in and do something on ..., they would be able to accommodate. And if I was doing the same, if they came to us, we’d be able to do something. And we will wander up to science department and say you know, we’re talking about steady state or big bang, have you got anything that we can look at, or this concept’s come up, or a student’s asked this question, how would you respond.* T/RE/A

School B was exceptional in having something concrete to show. Aided by a member of staff who taught in both departments, it was developing a Year 9 RE module that explicitly addressed the inter-relationship of religion and science primarily from a philosophical, psychological perspective. This followed a previous, disappointing attempt to introduce a course based on published resources that tackled the inter-relationship:

> Rachel: *... what did come out of it was the topic was obviously one that interests students [...] the whole thing about the overlap between scientific and religious ways of thinking was an interesting topic, but we just realised that that particular material was not the right material to choose. So that’s why we’ve decided to look this year at something more general about the natural world, and about how people describe and understand the natural world when they have religious ways of thinking, and then to look at how scientists also look at and explore the natural world.* T/RE/B

School C did not have an RE department as conventionally understood. School D was more typical of the survey schools, with no collaboration reported. Although the Science teachers claimed they were not averse to some co-operation, they argued that workload would make it impossible, and there was no sense of any real interest in the idea. The RE teacher was equally unenthusiastic, judging that he and his team were capable of making the necessary input along with the students:

> Dean: *... there are quite a few overlaps between the two and I try and marry up certainly the stuff we do in KS4 with what they study in Science [...] But it’s not a pre-planned sit down with the science department and look through. [...] I know Science is teaching from the scientific point of view and we’re teaching from a more philosophical or religious understanding. [...]*

> Researcher*: Do you think it's an area where it would be fruitful to have more collaboration or do you think it's not really a priority?*
>
> Dean: *I think – well, how we act at the moment is quite, it works, because pupils – it's getting the pupils to make the links rather than us telling them the links.* T/RE/D

The lack of inter-departmental collaboration suggested most schools were falling into the "silo" model that Waiti and Hipkins (2002) warn against (Section 5.2.2). Bernstein (1996) would describe this as a system with a strong classification of knowledge. As a consequence, subjects are clearly demarcated and isolated from each other, with their differences rather than commonalities being emphasised (Section 5.2.1).

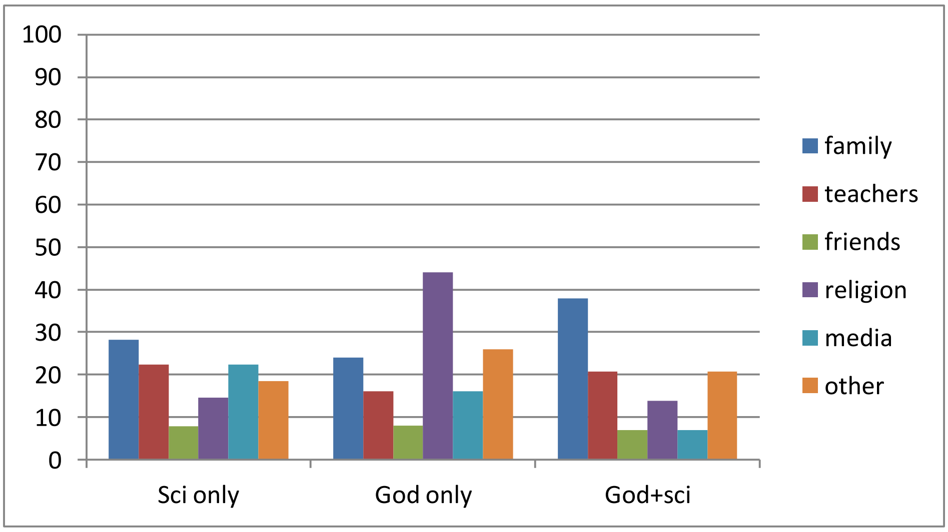
7.5 Are there differences between students' own religious or cultural beliefs about the origin of life and what they are taught in school? If so, how do they accommodate these?

7.5.1 Influences on students' views

When students in the survey were asked to select the factor that had most influenced their views about how life on earth had come into being, there was a wide range of responses. Despite encouragement to tick only one box, several respondents chose more than one, and because the figures are expressed as percentages of respondents rather than total responses, they can add up to more than 100%.

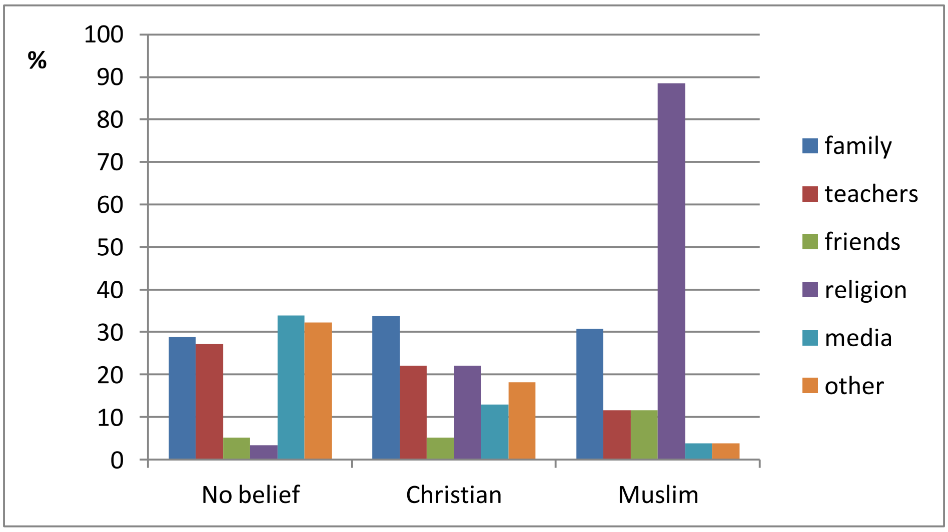
Figure 7.11 shows that those who accepted a scientific version of how life on earth came into being were more likely than the others to have been influenced by the media, although family and teachers were also prominent. For students who referenced only God or religious understandings, their religion was more influential than for the other two groups. Those who gave descriptions combining both the scientific and religious were more likely to be influenced by their family, and relatively unlikely to mention the media. Although around a fifth in each case wrote in other influences that were not itemised in the questionnaire, the nature of these varied by sub-group. Reading books and stories featured quite strongly for those giving explanations to do with God alone. Several of those who mentioned science or God and science declared they had come to their views through their own thinking. Similarly, Woods and Scharmann (2001) found that students who accepted an explanation of the origin of life that mixed science and religion were more likely to be influenced by their own logical reasoning rather than authority figures (church or teachers, for example).

Figure 7.11: Main influences on students' views by opinion of how life on earth came into being



The pattern of influences varied by belief group (Figure 7.12). Among those with no belief, media, family and teachers all had roughly equal prominence, between a quarter and a third choosing each. About the same proportion wrote in another explanation, mainly alluding to their own judgement (such as "*own views*", "*just what I think*" or "*no one influences me on these issues*"), with books/reading and science mentioned at a minimal level.

Figure 7.12: Main influences on students' views of topic by religious belief



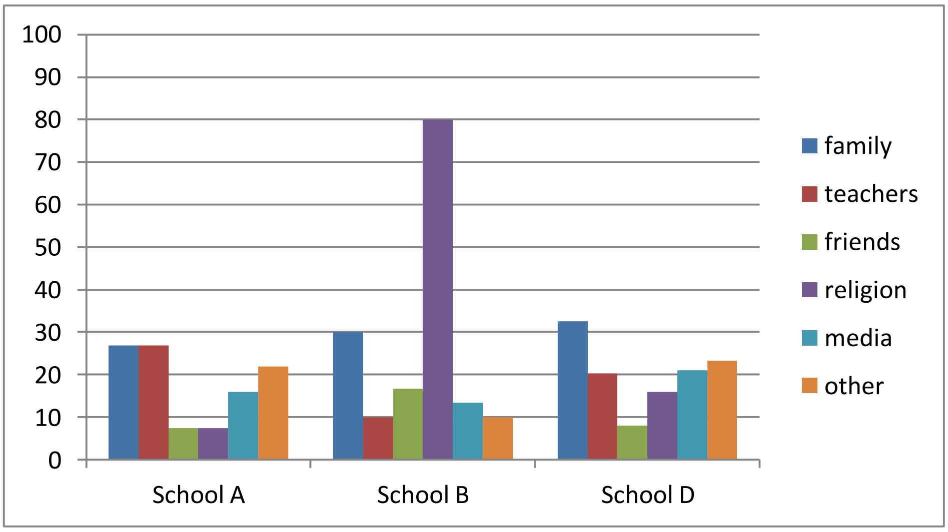
The most popular response among Christians was "my family", chosen by a third, with just over a fifth citing their religion as the main influence and the same proportion mentioning their teachers. The media was considerably less influential than for those with no beliefs. The types of comments made under "other" were similar to those previously described.

Nearly all Muslim students (88%) said their religion was most influential on their views of the topic. Although family lagged well behind at 31%, it was the next largest category and the figure was comparable to the proportion for Christians and those with no belief. The specific influences that were weaker on Muslims than the other two groups were the media and teachers.

As a factor in their thinking about the origin of life, school seemed to be much more pertinent to the Christian students and those with no religious beliefs than to the Muslim students. Teachers were a main influence for at least one in five of those with Christian or no religious beliefs, compared with one in ten Muslims. It would be interesting to explore whether this low level of teacher influence among Muslim students reflected a deeper alienation from school or school science, eg Costa's “Outsiders” (Costa, 1995) (Section 5.3.2).

An analysis of student views by school attended reflects the make-up of each school in terms of religious belief and opinion about origins (Figure 7.13). In School A, with its predominance of Christians and split between those holding scientific and mixed religious/scientific views, the main influences were family (27%) and teachers (27%). For the students of School B, the majority of whom were Muslim and attributed the origin of life to God alone, their religion was the key factor (80%) with, far less prominent but still sizeable, the family (30%). In School D, with its more fractured pattern of religious belief and majority acceptance of a solely scientific version of origins, family (33%) was considerably ahead of media (21%), teachers (20%) and religion(16%).

Figure 7.13: Main influences on students' views of topic by school



These figures were supported by feedback from the focus groups. References to religious upbringing were made by a number of the participants – sometimes to contextualise a position they had moved to:

> Lee: *Used to go to church a lot, yeah, but as I've got older new science has developed and explained a lot of it.* S/A1

> Nasima: *... we only believe in our religion [Islam] because our mum believes in it, our family believes in it, our parents believes in it. So if my parents were Christian then we would have believed in what Christians believe, their beliefs [...] I think we would believe in the big bang if we were atheists.* S/B5

In School C, Callum made a similar point about a myth that the world was carried on the back of a giant turtle, which he dismissed on the grounds of clearly contradictory photographic evidence from space. However, there was an acknowledgement that a person's background could affect this:

> Callum: *... but if you're brought up with it, I suppose you could actually think it's believable.*

> Sara: *Yeah, if that's all you've been taught to know then that's probably what you would believe. Because we've grown up going to school, and we know the other side of things ...* S/C4

The media, which was influential for a minority of students, was also mentioned occasionally in the focus groups – usually in the form of documentary or news programmes on television:

> Amy: *I watched a documentary on how life evolved and there was like these meteor rocks came down, I think they're in Australia now, and they were actually, they gave off oxygen that actually produced trees and stuff like that.* S/A4

It is interesting to note – although it was a relatively minor response category in both cases – that more of the students in School D than School A said their religion was influential (16% versus 7%), despite A being a faith school and D having a much higher proportion of students with no belief.

7.5.2 Student opinion about whether religious views should be covered in Science lessons

In the focus groups, students were asked how religiously-motivated challenges to scientific explanations of the origin of life should be dealt with in the Science classroom. Irrespective of their own religious beliefs, most felt that the primary concern was the respectful and sensitive treatment of the student, and consequently the teacher should acknowledge and engage with the students' beliefs:

> Amy: *You should kind of respect their religion. If they're really strong Catholic, then they might not like the idea of evolution or big bang, you might have to just slightly change it or view both sides of it, don't just stay on the completely scientific side.* S/A4

> Michelle*: ... if [the teachers are] saying that religion isn't part of science then they're saying basically that religion is wrong and science is right and you can't really tell someone that their beliefs are all wrong.* S/A2

There were two main caveats: the issue should only be covered if initiated by the student; and the scientific version had to dominate because this was what would be needed for the exam:

> Vicki: *I just think they should - if the student wants to discuss it, talk about it a little bit, but mainly just go on what you need for science.* S/A3
>
> Alan: *I'd say as long as the students know what they need to know to get their pass in science [...] then they can know as much as they want about the religious faith version of the story, so it's important to discuss it in science lessons if the child wants to.* S/A5

This pragmatic stance was also the approach adopted by many teachers (Section 7.2.2) and echoed the recommendation from Smith and Siegel (2004) that students who reject evolution need to be convinced that it is the best of the scientific explanations, rather than necessarily superior to all other possibilities (Section 5.1.2). It needs to be appreciated as a powerful explanatory tool that has profound implications in biology and beyond but, as Scharmann (2005) emphasised, "we should not be interested in whether a theory is 'true' only whether the theory works" (p. 13).

There was a minority opinion that religious views should not be covered in the Science classroom, because it would be confusing or unsettling. Rajhana, for instance, made it clear that she did not accept the scientific explanations but she would resent any attempt to raise the conflict explicitly:

> Rajhana: *I think they should keep it the way it is, the way that we only talk about scientific parts [...] you know I've been saying that we shouldn't have to question our faith, that's why I think we shouldn't talk about ethics, I think we should just learn about the whole process of the big bang, we shouldn't talk about the different religious views in science ...* S/B1

7.5.3 Student perceptions of teachers' views

Although one in five students said their teachers were a major influence on their thinking about how life on earth had come into being, the majority of respondents did not know whether their teacher would agree with their views – 62% for the Science teacher and 55% for the RE teacher. Those who did not think there was any divine intervention in the process were more inclined to think the Science teacher (31%), rather than the RE teacher (7%), would agree with them. The reverse was true for those who ascribed to God a role in the creation or development of life. How much this was based on actual knowledge of the teacher's views is a moot point. Comments in the qualitative work suggested that some students jumped to conclusions based on the department a teacher worked in. Laura (Head of Science in School B who also did some RE teaching), for instance, felt automatically labelled because of her involvement in both departments:

> Laura: *It's interesting because obviously now I've got a certain role and people see me as that, as going across both. They don't ask, they make assumptions, they make a lot of assumptions that well, I must be a Christian kind of thing.* T/Sci/B

Laura was adamant that she would not introduce her own beliefs into her teaching, whether in Science or RE, because it was "a bit out of bounds" and that her emphasis in the Science syllabus was student-focused:

> Laura: *[...] we're keen on getting their opinions and their thought processes, I don't think it's appropriate in that context for me to be putting my opinions in.* T/Sci/B

Most of the case school teachers held a view about the origin of life that combined acceptance of current scientific theory with some divine element. Only one (Phil, at School A) thought that his own opinions affected how he taught the topic, in the sense that he was keen to demonstrate (as teacher at a faith school) that the scientific and religious views were not necessarily in conflict. However, he insisted he addressed it in a way that would not exploit his position of authority as a teacher.

7.5.4 Teacher perceptions of student views

The teachers in Schools A and B were very aware that many of their students had religious beliefs, although they varied in their interpretations of how that might affect teaching and learning. There was a particular contrast in the RE department of School B. The perception of Rachel, the head of department, was that the students had an attitude that science and religion were in opposition and that scientific knowledge was automatically the version that was discounted:

> Rachel: *I think this whole stereotypical division between religion and science may possibly be more heightened in the minds of the Muslim students that we're talking about than it would be in perhaps a more secular setting. I feel that anecdotally, I have no empirical evidence to back up that statement, but that has been my experience. You know, the Qur'an is right, the Qur'an is true, and therefore by definition the scientific explanation must be false.* T/RE/B

Her own experience of teaching about the origin of the universe was that students had never considered that it might be possible to accept both the scientific and religious explanations, and that this came as a revelation to them:

> Rachel: *When we actually started doing big bang theory the whole thing about well, is it possible to hold both those worldviews in your head at the same time and in your heart at the same time, or does one exclude the other, had not really occurred to them. It was this automatic, the world cannot have come into being through the big bang because God created it and God made it happen. The fact that God could have caused the big bang as a possible notion was like "ah" [tone of surprise].* T/RE/B

Henry, who also taught RE in School B, had a very different opinion about the students. Throughout the interview, he was at pains to stress that he had never experienced any problems in the classroom, and he felt there was a historic acceptance of science in the

Islamic faith that was perhaps missing from Christianity. From his viewpoint, reconciling science and religion was not an issue in the Islamic tradition:

> Henry: *I don't think it's a problem for Muslims, you see, because they're seen to be complementary and part of their religious duty is to gain knowledge and it's not quite the same as the development of Christianity so because they're all Muslims they see them as complementary, the development of science, the development of religion.* T/RE/B

He stressed that he taught big bang and evolution "sympathetically" and as theory rather than fact. One of his main issues in the classroom was what he described as a lack of general knowledge, exacerbated by teaching students the theories before they were covered in the science classroom.

From their different standpoints, both RE teachers felt they had demonstrated to students that science and religion were non-conflicting. It was apparent from my discussions with students from School B that many of them recognised this complementary approach, although their response patterns suggest they were not necessarily convinced by it (Section 7.3).

Laura, Head of Science at School B, had experiences which were more in line with Rachel's. Some students would learn scientific explanations of the origin of the universe without really engaging, whilst others would argue against them. Still others took another line:

> Laura: *... lots of them will say my goodness, I've been told and believed this all my life, now I've been told this, how can I find a way of holding these together?* T/Sci/B

Phil, head of Science at School A (the Christian faith school), felt that his position as a teacher with faith was widely recognised in the school, because he took religious reflection sessions, spoke at the religious society, and was a member of the same church congregation as many of his students and their families. As such, he saw himself as a reassuring presence in the Science classroom who could "remove an area of conflict" by sharing his own personal explanations and analogies. These were designed to show students that their Christianity was not compromised by theories such as evolution and (in his experience, more controversially) the big bang.

Rick, Phil's equivalent in the RE department, took a different approach. He recognised the range of backgrounds of students at School A, but felt that most of them saw science and religion in conflict, whatever their religious standpoint. As an issue in RE, he felt it was not covered fully until the AS/A level course, so students doing the GCSE (compulsory at School A) had not necessarily had the chance to fully debate it.

For teachers at School B, having a religious dimension in Science lessons was not so much a choice as an inevitability. For the majority of their students, faith was so integral to their lives that the teachers' main concern was that students would not raise their objections and would passively, silently, reject the scientific arguments:

> Laura: *I have very very little of fundamentalism coming back at me, very little. So - but what concerns me about that is, that it's all silent.* T/Sci/B

Teaching science in a majority Muslim school, she was worried that her silent students were simply rejecting the scientific explanations out of hand:

> Laura: *I'm convinced that a lot of the ones who aren't raising it, they're just sitting there blanking out what I'm telling them. So okay, I'll learn this because I have to, the science - just not going to engage with this, just not true, it's just what the scientists are saying.* T/Sci/B

Laura's description suggests that resistance techniques such as Fatima's rules and silence (Larson, 1995; Jegede & Aikenhead, 1999), as discussed in Section 5.3.2, were present in her classroom. This was one of the reasons why the school was experimenting with a module that specifically explored the relationship between science and religion

Some teachers attributed the absence of debate to general agreement about the topic. In School A, Head of Science Phil ascribed this to the level of homogeneity of students' Christian beliefs (although Rick, his RE colleague, was much more aware of the diversity that existed). Phil drew comparisons with his previous experience at a secular school where the greater range of student belief systems had stimulated more discussion:

> Phil: *When I worked at a non-church school there was more of a debate because you would have I think a bigger range of beliefs and more of them.* T/Sci/A

However, the teachers at School D also assumed a consistency among their student body, one which gave no credence to supernatural, and certainly creationist, views:

> Dean: *We show them video clips of the creationist museum in America and the idea that the Grand Canyon was caused by Noah's flood, and say look, from what you know of science, would you agree? It's quite interesting to hear their points of view.*
>
> Researcher: *What sort of things do they tend to say?*
>
> Dean: *I think they're quite open about - I think they find it quite difficult in a scientific age to understand how people do believe in a story that's quite fantastical.* T/RE/D

The lack of explicit challenge reported by teachers in Schools A and D, where the questionnaire responses suggested a significant minority did not accept the scientific orthodoxy, implied that passive resistance methods such as silence and Fatima's rules were not confined to School B. Furthermore, there was a danger that this was going unnoticed and therefore untackled at School D. The concern in educational terms is not that students may be rejecting evolutionary theory, but that they are failing to gain an understanding of it because the tactics they use to avoid unwelcome challenge automatically lead to reduced engagement.

7.6 Summary

One of the most striking findings to emerge from the data reported in this section is the wide range of viewpoints expressed by the teachers in the survey. The lack of bunching at one end of the various response spectrums also provides reassurance that the sample does not represent just one faction of opinion. However, this variation in response pattern underlines the complexity of the issue and difficulties implicit in finding an approach that will suit all teaching staff, before the additional layer of complexity represented by the students is even added.

There was a spread of opinion amongst teachers about whether or not the origin of life was a controversial subject. Science teachers were slightly more likely to perceive it as contentious, and had significantly more experience than RE teachers of it actually being controversial in the classroom. This was mainly a result of students with fundamentalist, literalist religious views and also the challenge of managing the range of views expressed. For many (especially RE teachers), this was a challenge they enjoyed.

Most Science teachers were mentioning religious beliefs to some extent in their lessons about the origin of life, although their confidence in covering the area was sometimes lacking. Likewise, most RE teachers were including scientific explanations – but they expressed what might be interpreted as a worryingly high degree of confidence. Training and support could be useful to give Science teachers more self-assurance and to make sure RE teachers have a firm grasp of the science behind the topic.

The balance of both Science and RE teachers thought it important to cover religious beliefs about the topic in the Science classroom, but this was taking place in the context of a general lack of collaboration between the two departments. Students tended to think that Science teachers should deal with the religious issue if it was raised, with the main consideration being respect for the student's belief system.

Several students confused the origin of life with the origin of the universe. Students at the majority Muslim School B, particularly in the survey, were overwhelmingly of the view that God had created life on earth and human beings pretty much as they are today. Opinion was more mixed in Schools A and D. Although a higher proportion at School A (the Christian school) thought there had been divine involvement in a human evolutionary process, and School D instead opted for evolution without a divine aspect, a minority in each setting thought humans had been created by God in their current form.

It was clear that a variety of views existed within both student and teacher populations. The underlying subtleties were not always appreciated: students tended to make assumptions about teachers depending on the subject they were associated with, and some teachers seemed to generalise about the school population in a way that might not be beneficial to those being overlooked, perhaps exacerbating a “culture of silence”.

The next two chapters investigate the data for underlying patterns, identifying commonalities and exploring how these can be built into more cohesive, coherent frameworks.

8. Analysis 2: Conceptualisations of Science and Religious Education

The data revealed some clear themes relating to the attributes linked to different school subjects. These were developed and elaborated during analysis. This chapter reports on the four dimensions that emerged as important in characterising the differences between school Science and RE. Three of these relate to the perceived fundamental nature of the subjects, and the fourth to the way each portrays the inter-relationship of science and religion (see Figure 8.1). This background context helps shed light on the third research question which sought to identify any differences between how Science and RE classrooms dealt with the origin of life.

The next four sub-sections describe each dimension in more detail and present the data which support the model. Inevitably, there is a neatness here that belies the reality. The proposed framework has been based primarily on student comments about teaching and learning in the two disciplines. However, individual students were not always consistent in their views nor did they necessarily conform to the generalisations made below about the positioning of each subject on the scales.

Figure 8.1: Four dimensions characterising Science and RE

Dimension 1: foundation of knowledge

fact ↔ belief

Dimension 2: tolerance of uncertainty

need resolution ↔ accept discomfort

Dimension 3: open-mindedness

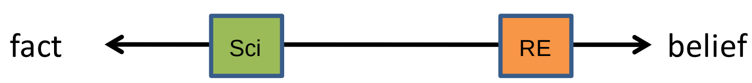
unquestioning ↔ inquiring

Dimension 4: nature of Science/RE relationship

competitive ↔ in harmony

8.1 Dimension 1: foundation of knowledge

Figure 8.2: Foundation of knowledge dimension



During discussions it became apparent that the students associated Science and RE with very different types of truth claims. The labels for either end of this spectrum have arisen from a distinction many of the participants made during the study between ‘belief’ and ‘evidence’:

- ‘belief-based’ knowledge systems privilege what is known by faith and expressed through experience and writings.
- ‘evidence-based’ knowledge systems were described as those backed up by facts, observations and experimental evidence.

Science was perceived to be based on fact underpinned by evidence, whereas RE was coupled more closely to opinion and belief, as shown in the following exchange:

> Lee: *In science he told us like it was a fact, in RE he told us it like as a …*
> Samuel: *Like people believe this.* S/A1

This distinction is reminiscent of what Peters (2006) refers to as the two-languages model, with science corresponding to the language of facts and religion to the language of values (Section 2.3).

An important element for some students was that scientific claims were more likely to be backed up by observable phenomena than were religious claims. Even amongst those who acknowledged this distinction, there was a widespread tendency for the term “belief” to be used with regard to science as well as religion. Scrutiny of the context demonstrated that, although the same wording might be used, it was being defined differently:

> Jessica: *Science seems more believable though because ...*
> Gayle: *… they can prove it*
> Jessica: *When you do a science experiment and you can actually see how things change you kind of believe it more scientifically than religiously.* S/A4

> Tina: *I’m one of these persons that have to see things, well mostly see things to believe things and stuff.*
> *Researcher: So you want ..*
> Tina: *Evidence and stuff like that. And with science and evolution, there’s loads of evidence to back it up and that. With religion it’s more like a belief.* S/C1

This linguistic ambiguity was not confined to students. A small number of RE and Science teachers in the survey referred to “belief” in scientific explanations. Both heads of department at School A discussed whether or not students “believed in” evolution. Such laxity with language was anathema to Laura at School B. She described how she enforced a ban on the word “believe” and its derivatives in some Science lessons to reinforce the importance of language and the existence of different value systems. In direct contrast, one Science teacher in the School D focus group argued that some science was a “*matter of faith*”. His colleague supplied the illustration of stars that could not be touched or reached so information about their properties had to be taken on trust. This was not a theme that other members of the group were prepared to endorse, although it was alluded to in a few questionnaire responses:

> *Science is a belief system!* T/RE/q63

It was proposed in Section 5.1.2 that it would be more appropriate to refer to the "acceptance of" rather than "belief in" evolution, because, in the words of Sinatra et al. (2003) the latter might imply that "judgement of the validity of the theory is based on personal convictions, opinions, and degree of congruence with other belief systems" (p. 512). With its relationship to the different underpinnings of Science and RE, this dimension reinforces the importance of considering the epistemological basis of the two realms.

For those students who readily accepted scientific explanations as having a strong factual basis, their assessment of Science as a much more legitimate endeavour than RE pushed the subject positions on this dimension further to either end of the spectrum. Even those who were less convinced of the validity of science tended to see it as more fundamental to their education and consequently more important. Most saw the purpose of studying science as being to pass an exam and add to their tally of GCSEs, meaning it was characterised by knowledge acquisition through the absorption of a series of facts. The same did not apply to RE, even though study to GCSE level was compulsory in Schools A and B:

> Darren: *Science is more about facts and religion, RS [Religious Studies] and RE, is more kind of your own personal opinion. In RE you didn't have to learn a lot of facts, in Science you have to learn a lot more facts, and part of RE is some of your own - erm - your own, what you think.* S/D1

This determined how they felt religious objections to scientific theories about the origin of life would be handled in the Science classroom – treated with respect but clearly differentiated from learning that would be legitimate in the exam:

> Brett: *I think [Science teachers] would have gone along the lines of, that's your view but if you want to pass the science test you've got to – not believe it necessarily but understand this theory [evolution]*. S/A1

From the survey, it was apparent that some RE teachers (and a few Science teachers as well) characterised the scientific approach as dogmatic and unarguable. Consequently, they concluded that Science teachers were unlikely to have been trained to deal with controversial issues and furthermore it was not a competency they needed:

> *Science is about fact and proven understanding.* T/RE/q43

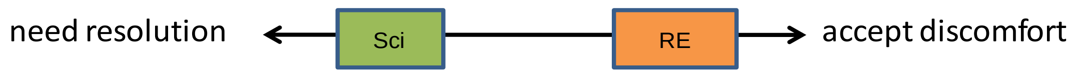
> *Science is a factual subject not a subject about opinions and personal beliefs.* T/Sci/q40

A very small number of Science teachers in the survey recognised that controversy had been sparked by their own lack of sophistication when dealing with the evolutionary theory, as illustrated by this quote:

> *Once taught a fundamentalist - usually I approach the 'theory of evolution' as fact! This has only ever happened a couple of times, most pupils don't tend to bring religious beliefs into it*. T/Sci/q22

8.2 Dimension 2: tolerance of uncertainty

Figure 8.3: Tolerance of uncertainty dimension



The sense of Science as an objective, factually-based discipline alluded to in Section 8.1 contributed to a widespread feeling that Science always demanded one single acceptable answer. This must be learnt and recited to earn exam marks. The scientific version could not be challenged and was not open to opinion. Some found this approach blinkered and frustrating:

> Vicki: *I think that in science they kind of only explain one side of the argument, they don't tell you what different things could have happened.*
>
> Hannah: *I sort of expect it because that's what we need to cover in an exam, but it's a bit annoying because you don't know which one to believe.* S/A3

RE, in contrast, was seen as encouraging the expression of opinions, with the aim of rehearsing and exchanging viewpoints before coming to a personal decision about an issue. Unlike Science, there was no single correct or approved answer, one student describing it as "*what you think is right or wrong based on your conscience"* (Taruna, B5). Nor did students seem to expect or need resolution in the same way as they might do in Science:

> Vicki: *[in RE] you just argued the different points - I can't remember actually coming to a conclusion.* S/A3
>
> Nat: *Well in [RE] it's normally like a debate, they ask us questions and that. It's mainly the teacher talking at us but we get our own opinions, we put up our hands, we have little group discussions, and whole group discussions, us as the class, debates and stuff.* S/C6

This distinction between the two subjects in terms of tolerance of a range of views was reinforced by many RE teachers in the survey. It was also supported to some extent in all the case schools, despite the presence of relatively close links between departments in Schools A and B. Although the head of RE at School A considered it well within an RE teacher's remit to discuss the relevant scientific theories about the origin of the universe, he felt that the RE department was better equipped to deal with the religious explanations. Pressed to justify this stance, he revealed a perception of the difference between the RE and Science classrooms that very much fitted with that expressed by the students:

> Rick: *I think, maybe this is my own ignorance in terms of science teaching and the way in which science works, but there is – RE is used to looking at differences in*

> *viewpoint and opinion, evaluation of different viewpoint and opinion I suppose, the sort of base rules that students have when they walk into an RE classroom is around listening and respecting one another's viewpoint. Not to say that that's not true of the science, but I think that maybe the skills that students develop in RE might be better suited for that sort of lesson. But that could well be down to my own ignorance of what happens in a science classroom because I don't get to go into other classrooms as much as I'd like.* T/RE/A

A perception that Science was about the "how" and RE about the "why" underpinned the assessment of where each subject sat on this dimension. The "how" lent itself to technical, factual answers and the "why" to more philosophical approaches:

> Shelina: *In science it's different because in science you do things about earth and the atmosphere and everything around you, but in RE it's more like you get into it and you discuss and compare and everything's different compared to Science and RE. In RE you're more into the why and how did they believe in it, why did they believe, and what do you believe in and then you compare it together and then discuss that. Science they don't really compare as much.* S/B5

Teachers and students indicated that different approaches were being used to tackle the topic in Science and RE. There was a sense that the format of RE instruction was less prescribed and more open to serendipity to determine the course of the lesson. RE teachers were more likely than Science teachers to speak of developing their own resources (PowerPoint presentations or material for the interactive whiteboard) and using video:

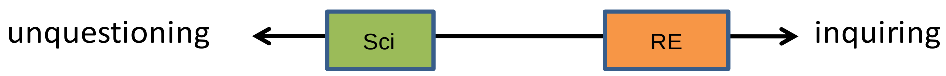
> Rachel: *And that came out of the students because we were first talking about this creation thing, this slide sequence, and one of the kids said, "Hey miss, did you see that thing with Stephen Hawking?". Well, I happened to have it [video of the programme] anyway cos I'd brought it in to see if I could do anything with it and so I put it in and played it.* T/RE/B

Rick, the RE teacher at School A, was deliberately encouraging students to contribute their own opinion to the debate about whether scientific theories were compatible with a belief in God :

> Rick: *... so we'll look at that and say why do some people believe that a scientific explanation for the origin of the universe could challenge belief in the existence of God, and then we'll look at how people might respond to that and have a discussion across viewpoints within the class ...* T/RE/A

8.3 Dimension 3: open-mindedness

Figure 8.4: Open-mindedness dimension



Consistent with the view of Science as a fact-based subject with clear right and wrong answers, students perceived it as closed to question or argument. In contrast, RE was described very much as a discipline that did not merely tolerate challenge but encouraged it. These opinions were supported by the reported pedagogical styles in the classroom. Accounts of RE lessons on origins were dominated by reference to discussion, with mention of direct instruction from the teacher at a low level:

> Researcher: *And again, what kind of lesson was it, what did you do in that lesson or those lessons?*
>
> Sumaya: *Class discussions, yeah, class discussion*
>
> Rajhana: *There was a class discussion*
>
> Sumaya: *And debated topics that came up*
>
> Rajhana: *We just basically discussed what we thought and a Christian or a scientist*
>
> Sumaya: *And how they compare to one another.* S/B1

Stark comparison was drawn between the two learning approaches – the transmission model in Science and a more constructivist style in RE:

> Hannah: *... in RE you get to discuss it and find out for yourself but in science it's just "This is it, got it?, that's what it is".* S/A3

Various media featured in descriptions of RE lessons, such as video, drama and internet as well as textbooks. By contrast, there was an emphasis on teacher talk and use of textbooks and worksheets in Science lessons with the students' role being much more passive and the opportunity for voicing their own opinions consequently reduced:

> Researcher: *So did you talk about it in science as well?*
> Tom: *Not as much discussion*
> Alan: *Just learning it rather than putting forward ideas.* S/A5

Some reported that Science was very much a one-way process, and contrasted this unfavourably with their RE lessons:

> Shannon: *We hardly do writing in that [RE] class, it's just like all discussion, innit? Like, agrees and disagrees and stuff*
> Becky: *We all discuss it and it's like a debate and stuff but it's really good ... You don't get chance to ask questions in Science.* S/C8

This characterisation of Science classes as being less receptive to open and creative discourse than RE suggests that student conceptions of appropriate behaviour in the subject have remained unchanged across many years. Exploring the friction between cross-curricular themes and subject-based curricula, Whitty, Rowe and Aggleton (1994) recorded the following conversation comparing Science with English:

> Pupil I: ... the [Science] teachers restrict you, they say don't, you know, try to talk about anything else other than what you're working on so if you talk about what you're working on it's got to be different from what you're working on in English.
>
> Pupil II: Well in English you come up, you try to come up with creative ideas, so you can talk in a creative manner, in science you talk in a more logical manner ... analytical. (p. 173)

However, several students in School C reported that they had been given a chance to describe different ideas about the origin of life in Science by compiling a newsletter or a PowerPoint document, using information from the internet. They had compared Darwin's theory of evolution with ideas about Lamarck, meteorites and God creating life. Some described the exercise simply as writing an essay, but a few students remembered an accompanying discussion:

> Researcher: *Can you tell me a bit about that lesson?*
> Callum: *I think we got two theories. There was evolution, we did a couple of the evolution things, and there was we come here from space and the meteorite*
> Sara: *We also said what we think happened, we discussed it, what we thought had happened*
> Researcher: *Were there any other explanations came up when people discussed what they thought might have happened?*
> Sara: *Erm - there was God and evolution and*
> Callum: *Space*
> Sara: *Space. All different theories that everyone had different opinions, it was quite interesting to see what everyone else thought.* S/C4

Although students were being asked specifically about the teaching around the origins of life and the universe, some of their responses suggested that they were generalising about the pedagogy in a way that reflected their overall perception of the two disciplines. There was a sense that their experiences of the subjects had changed over the course of their schooling, as they had matured and been exposed to more ideas:

> Kelly: *I'd say I've developed too actually. When I was younger I used to think…*
> Alexa: *Yeah, when I was younger I think you just believed what you were told. Because they didn't – you don't get taught Physics in primary school but RE has always been a core subject. [Then] in Science you get told and then you believe that.* S/D2

The common student perception of science as unquestioning finds echoes in Feyerabend's comments about the dogmatic nature of science education originally from a 1975 article (Feyerabend, 1999):

> Scientific 'facts' are taught from a very early age and in the very same manner in which religious 'facts' were taught only a century ago. There is no attempt to

> waken the critical abilities of the pupil so that he [sic] may be able to see things in perspective. (p. 182).

The teacher interviews and lesson observations did not contradict the student feedback, although the scale of the research was too small to draw any categorical conclusions. When Science teachers described how they tackled the origin of life, the emphasis was very much on how they dealt with it sensitively to avoid unsettling the students, rather than how they involved the students which was more the priority for RE teachers. This is demonstrated by quotes from the respective heads of department at School A (the Christian school):

> Phil: *Because I do reassure, I think my priority is often to reassure students with faith that I'm not teaching them something that's contrary to their faith. I tend to give three sort of, explain three standard viewpoints which tends to be there is a viewpoint which says that the Bible is a factual recount of what went on, there's a viewpoint that the Bible is all wrong and is words mistakenly written by humans, and there's a viewpoint that says that both are mutually compatible and I often say well I'm not going to preach to you but that's where I feel the correct place is, but as long as you can understand those ideas then it's your job to make your decision.* T/Sci/A

> Rick: *They also look at the challenges to belief in the existence of God and one of those is actual scientific explanations for the origin of the universe and does that in itself challenge belief in existence of God. And so we'll look at that and say why do some people believe that a scientific explanation for the origin of the universe could challenge belief in the existence of God. And then we'll look at how people might respond to that and have a discussion across viewpoints within the class and look at two sides of the discussion.* T/RE/A

The lessons observed in School D (the non-faith school) fitted into the broad pattern outlined. The structure of the Science lesson gave little opportunity for students to contribute as most of it was lecture style. The only chance for student interaction followed a 10 minute period of individual completion of worksheets, and the discussion was confined to suggesting and critiquing the answers. The teacher claimed that the students were usually livelier, ascribing their muted behaviour to the very hot weather and them being on their "best behaviour" for me. However, there were few opportunities for them to get actively involved. Both the RE lessons observed at the same school included a substantial element of quite animated whole-class discussion. It also featured a worksheet exploring the perceived status of different statements in terms of degrees of proof (the aim being to develop an awareness of when it is appropriate to use words such as evidence, knowledge, belief).

The Science lesson in School B (Muslim majority school), taught by Laura, was unusual in that it was designed to enable students to compare the evidence bases for the big bang theory and for other explanations of the origin of the universe. Pairs of students were assigned to explore one or other of these, then to discuss with a pair doing the alternative task before presenting their findings. One or two students were keen to call me over and share their views *("How come the earth is exactly right for us?"; "I don't believe in the big bang but the Maths teacher says you can believe in big bang theory and be a Muslim"*). The format of the lesson was not necessarily typical and the teacher admitted she had never before used copies of the Qur'an in the science labs, suggesting my presence may have influenced lesson planning. However, although the lesson was designed to encourage an open-mindedness around scientific and religious explanations, there was no indication that it had provoked much genuine inquiry. This comment from Asma was typical of those made to me:

> *Why do people want to know [the origin of the universe] so long as it's there now? It just confuses us.*

Laura was the only one of the Science teachers who emphasised the role that discussion played in her lessons, designed to challenge the primarily Muslim student population who were less receptive to some scientific propositions:

> Laura: *Lots of discussion. Lots of getting them to take positions that they wouldn't necessarily be comfortable in.* T/Sci/B

The other Science teachers described approaches that relied mainly on explanation from the teacher, with the rider in School A that possible conflicts with faith positions were acknowledged within that discourse.

The teaching strategies observed and described in the case schools represented all three of the categories outlined by Bridges (1986) for teaching controversial issues: procedural neutrality, affirmative neutrality and advocacy (Section 5.1.5). There was no sign that any teacher defied the English curriculum and fell into Hermann's additional fourth category for dealing with evolution, which is avoidance of the topic (Hermann, 2008).

Procedural neutrality seemed to be the dominant style for most of the RE teachers when tackling this topic. Rick, Rachel and Dean all described their role as an impartial facilitator, encouraging students to explore information and evidence and debate their ideas. When Dean was observed, his neutrality was a mix of student-led (procedural) and teacher-led (affirmative). Henry differed from the other RE teachers interviewed, indicating that he acted as provider of information in a role more akin to affirmative neutrality.

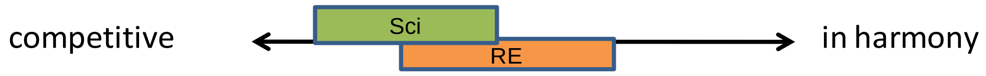
From their own accounts, the advocacy approach was being adopted by most Science teachers. In School D, this resulted from a lack of recognition that any position other than the scientific standpoint merited being taken seriously. Alice, who taught the observed Science lesson in School D, was an exception to this, following more of an affirmative neutrality approach. In reaction to the strongly pro-religious views of her colleagues and at least one of her students, Isobel engaged in fierce defence of a naturalistic explanation of the origin of life in her classroom. In School A, Phil approached advocacy from a completely different perspective. Championing his own overtly Christian views, his aim was to persuade his religious students that their beliefs were not threatened by the scientific explanations.

The literature on controversial issues recognises the importance of acknowledging and respecting other individuals' beliefs so they can be constructively debated (Hermann, 2008; Levinson, 2006; Oulton, Dillon, & Grace, 2004). Consequently, the danger of an advocacy approach is that the position power inherent in being a teacher risks overwhelming or alienating students who hold alternative opinions, hampering fruitful discussion.

Laura at School B was adamant that she did not reveal her own position to the class whether she was teaching Science or RE. In the observed Science lesson, she clearly set up the student task from a position of procedural neutrality, facilitating investigation and debate in small groups. Nonetheless, the way she manipulated matters to reach a conclusion that was in line with her own opinion – that science and religion exist as separate entities based on different forms of evidence - belied the professed neutrality of her stance.

8.4 Dimension 4: nature of relationship between Science and RE

Figure 8.5: Relationship between Science and RE dimension



This dimension describes the way students felt Science and RE portrayed the association between themselves as curricular areas of study. The increased length of the bars representing the disciplines shows there was less conformity about this dimension than the other three. To an extent, it was obvious from some of the comments made that there was a blurring of the distinction between Science and RE as school subjects and science and religion as broader concepts in the everyday world.

On the whole, both subject areas were seen as tending towards mutual discord, a position familiar from "warfare" models of the science and religion relationship found in the literature (Section 2.3). There was a sense that, to some degree, they were in a contest for hearts and minds. This linked in with some students' conceptualisations of science and religion as inherently oppositional. Confusion was often reported to be a consequence of this:

> Researcher: *So when in [RE] you learn about religious explanations does that confuse you at all or do you fit them together well or?*

Tony: *A little bit. Yeah, sometimes it confuses you*
Owen: *Yeah, sometimes*
Tony: *Like, when you say what our Science teacher said and they say, oh no that's wrong it's this and this. And then we come back and they say no, it's right.* S/C10

The Head of Science at School A was not the only teacher to report students behaving in a way that presumed science necessarily negated religion:

Phil: *I regularly get asked by students why do you work in a church school if you're a scientist, their assumption being that I must be an atheist, I don't believe in God at all. And I regularly explain that that's not how I see it at all.* T/Sci/A

Phil made frequent references to his duty, as a Science teacher addressing a high proportion of Christians in a faith school, to support students in finding a way of reconciling their religious views with scientific explanations. He felt this was important in maintaining students' respect for him and his branch of learning:

Phil: *I would reassure students that [...] what I'm trying to explain and work with them isn't in conflict to what their faith tells them because that would be quite a challenge to be courteous, polite and in a school environment with something that they perhaps passionately thought of as wrong, if I were to say well actually what I'm saying to you now goes against what your parents might be telling you, what you might hear in church.* T/Sci/A

Phil took this approach from the perspective of a practising Christian, but as Head of Department he also encouraged teachers without faith to air this viewpoint and he found that such staff, acknowledging their position in a church school, were happy to do so.

Some students believed that there was some thinly disguised competition between their Science and RE teachers:

Amy: *[...] in RE lessons and Science lessons they respect the others' opinion, but they kind of push theirs forward.* S/A4

Although not made explicit, there was an undercurrent of unease or even rivalry between Science and RE departments in a few of the questionnaire responses. For instance, some RE teachers were concerned that their Science colleagues presented scientific explanations as proven and indisputable when, like RE, they formed *"a belief system"* (T/RE/q63) or "*another world view*" (T/RE/q85). One of the Science teachers at School D, in talking about how the topic was covered, envisioned it as a contest between the two departments:

Tony: *I hope they [RE teachers] don't teach it more strongly than we do – that wouldn't be fair*

Researcher: *What exactly do you mean?*

Tony: *Well, that if they only put the religious side – but then I suppose we only put the science side.* T/Sci/D

However, in one of the focus groups at the same school, students were appreciative of the efforts their teachers made not to be dogmatic, putting this down partly to the personal beliefs of the teachers:

> Kat: *I think the teachers were quite good, that they didn't - in RE, they weren't all this is how God did it, and in science they were no that's not right, I think they were good that they sort of accepted alternative ideas*
> Tamsin: *I think they're careful of it, aware that*
> Alexa: *Because obviously some people are more religious and they knew that so [...]*
> Tamsin: *Also, I don't think any of our RE teachers are that religious so if they'd been more strongly religious they might have been more, this is what happened, if that makes sense. They were just teaching the curriculum.*
> Kat: *Yeah. And there wasn't any...*
> Tamsin: *Imposed...*
> Kat: *...influence, they don't try to influence us the teachers to be religious.* S/D2

Other students thought the subjects were presented as potentially complementary. This was particularly apparent at School A, where some felt that attending a Christian school meant the staff were less likely to treat the two disciplines as conflicting because of their own faith position:

> Charlotte: *Well they talk about, both of them, not which one's right and which one's wrong, but how they could both be right or how they could both be wrong*
> Researcher: *And what subject - is that in RE or in Science?*
> Charlotte: *In RE is when we talk about both. Not in Science.* S/A2

> Tom: *[...] when we were studying the topic in RE, somebody asked our Science teacher what he thinks and he says that he believes in both science and religion still as one so God could have started it off but science then fell into place to help, could be balancing and matching each other and helping*
> [...]
> Michael: *Yeah I think because it's a Catholic school, Science teachers as well have an RE view to it as well, so both join together.* S/A5

Nevertheless, how it worked in practice was very dependent on individual students and especially teachers, as demonstrated in School B which exhibited arguably the closest links between the two departments. A recent episode had soured relations between the RE department and one specific Science teacher who had treated the possibility of miracles dismissively. A religious student had found his manner contemptuous and distressing, and she had mentioned it to the RE staff. Although it was only an isolated incident and the teacher had previously seemed respectful, it prompted comments from the RE staff about the "*brittle and insecure*" nature of some Science teachers that led them to respond in such a way. As a result, one RE teacher remarked bitterly, "*we don't teach confessional RE* [ie from a particular faith or doctrinal viewpoint] *but they teach confessional science*".

Feedback from teachers and students in School D, and to a large extent in School A, suggest that the two disciplines did not tend to share a common pedagogical approach, and valued student contributions differently. Looked at in terms of Bernstein (1996), they had strong subject boundaries, with Science and RE well insulated from each other (Section 5.2.1). The framing of RE was weaker than that of Science – that is, in RE control over communication seemed to lie more with the student and less with the teacher, whereas the reverse was true in Science.

Conscious efforts had been made in School B, with its high percentage of Muslim students, to weaken the insulation between the two subjects. However, the strategy was largely confined to introducing a joint course juxtaposing science and religion as bodies of knowledge. At this stage, there was no intention to initiate a change in approach across the two sets of staff more broadly, and without this wider commitment the same topic would still be covered in uncoordinated ways in the two departments. In Bernstein's (1971) terminology, the curriculum remained a collection type rather than an integration type which would have introduced cross-cutting themes more widely and systematically.

8.5 Summary

This chapter outlines a model with four dimensions to illustrate how students characterise Science and RE. They associated Science with truth claims based on fact, evidence and proof, whereas RE was seen to be more based more on beliefs. In terms of language used, however, it is interesting to note that students often referred to "believing" in science. It was felt that Science put forward a single version of the truth and needed resolution, whereas RE did not demand one sole solution. It could handle challenge and grey areas, allowing it to tolerate uncertainty. In a similar vein, Science was closed to question or argument, whereas RE actively encouraged curiosity and questioning. Students reported that the subjects used teaching approaches that complemented these features, being more passive for Science (teacher talk and textbooks) and more interactive in RE (discussion and debate). They perceived the two disciplines as being in competition, and this was reinforced by some of the teacher comments. Even in School B, where the relationship was unusually collaborative, there was an undercurrent of disharmony.

Although these views sum up the overall picture that emerged, there are two qualifications: individual students differed from the broad consensus; and findings have been extrapolated from discussions that were almost exclusively about the origin of life and the universe rather than other parts of the Science or RE curricula.

One of the key messages that emerges from this chapter is that many students have an impoverished view of the nature of science (Section 2.2.1). There was a focus on facts and the importance of an evidential basis with only a limited recognition of science as being tentative, subjective or creative. This is despite growing emphasis on scientific literacy and the nature of science in recent curricular development (Ratcliffe & Millar, 2009; Ryder & Banner, 2011). Students' conceptualisations of the natures of science and religion will affect how the two are perceived to inter-relate at the personal and school levels. These matters are explored further in the next chapter.

9. Analysis 3: Developing typologies

In this chapter, two typologies have been proposed. The first, the inter-relationship typology, incorporates four types based on their different positions regarding the connection (if any) between science and religion. The second, the typology of engagement, categorises students by their preparedness to engage with that inter-relationship. In some instances, the same data fed into both typologies as a single comment might shed light not only on a participant's view of the science/religion inter-relationship but also to what extent they were willing to engage with it. However, the typologies are distinct in nature as well as content, with the first being more conceptually-based and the second more a reflection of attitudes and behaviour.

The typologies were constructed using a process similar to that described by Kluge (2001). Initially, dimensions were developed and participants who occupied similar places on each dimension were grouped together. Relationships between the different dimensions were then scrutinised and used as the basis of creating the different types within the typology. The aim was that each type would include participants that were very similar to each other, whilst being totally distinctive from the other types.

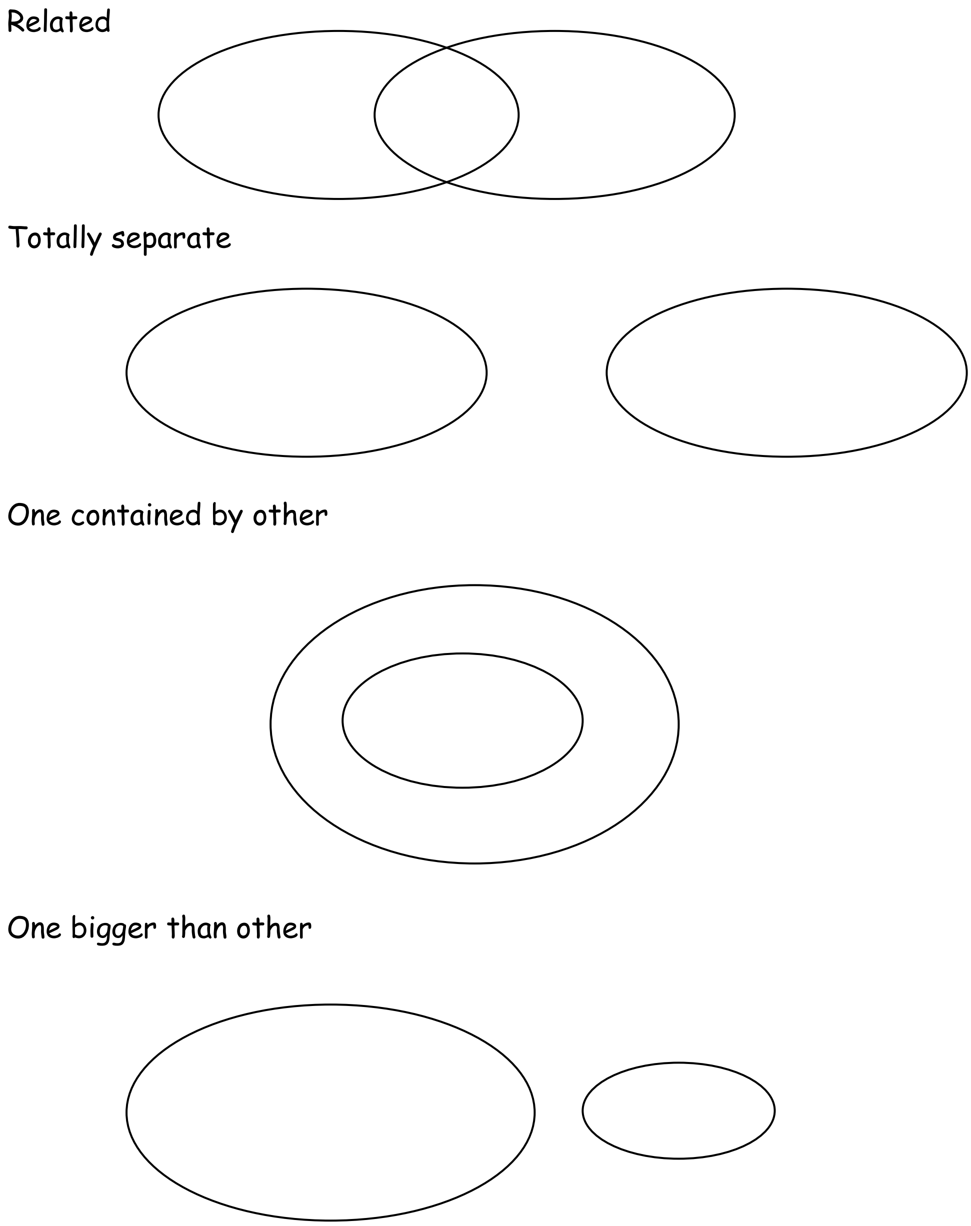
The evidence for the analysis is presented grounded in the data, and the thought processes illuminated. However, it should be noted that the typologies are illustrative rather than definitive. Moreover, people do not necessarily occupy static places within the models and there may be some fluidity as they drift between categories due to developments such as increased level of maturity and changes of perspective.

9.1 A typology of the science and religion inter-relationship

9.1.1 Visual representation of inter-relationship

Students were asked to draw a representation of how they visualised the relationship between science and religion. To give some guidance, they were shown four possible models (Figure 9.1 overleaf) but it was stressed that they could use an illustration of their own if they felt it more appropriate.

Figure 9.1: Examples of inter-relationship



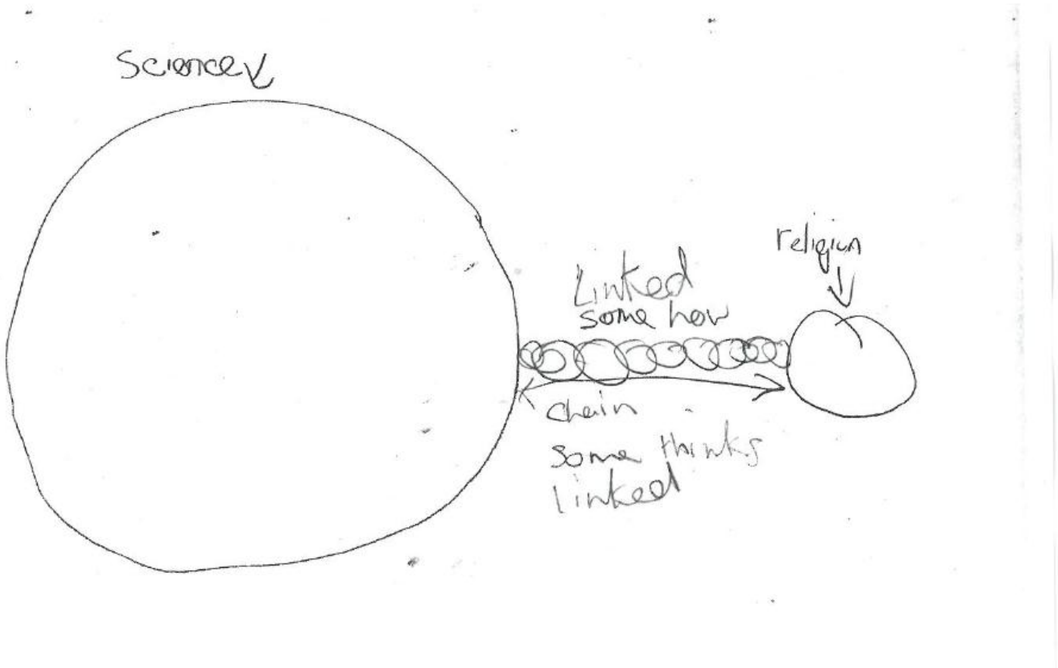
It was possible to categorise all but two of the resultant drawings using a three by three matrix, which shows the relative size of the two areas versus their inter-relationship (Table 9.1). The categories are self-evident, except for “partial overlap” which includes diagrams that showed science and religion as separate entities linked by a line or chain as well as those that actually overlapped (see Figure 9.2 for an example).

Table 9.1: Student representations of science and religion by school

		Inter-relationship of entities			
		separate	partial overlap	total overlap	
Size of entities	religion bigger		**A** **B** **C**	**AA** **BBB**	8
	equal size	**AAAA** **CCCC**	**AAAAAAAAA** **BBBBB** **CC** **DDDDD**	 **B**	30
	science bigger	**A** **CCCCCCCCC** **D**	**AAA** **CCC** **DDD**	**A** **C**	22
		19	33	8	

A – School A student
B – School B student
C – School C student
D – School D student

Figure 9.2: Drawing classified as science/religion partial overlap



Only eight students represented religion as bigger than science, and all but one came from School A (majority of students self-defined as Christian) or B (majority Muslim). The exception was Rosie, a Mormon from School C. Five out of these eight thought religion totally subsumed science. The largest group (30) represented science and religion as equal in size, with the majority of them showing the two as overlapping (21/30), although 8 drew separate entities. The remainder (22) portrayed science as larger, with most of them showing the two as either totally separate or partially overlapping. Notably, no student in School B portrayed science as being larger than religion.

Most students in Schools A and D showed the two entities as partially overlapping. Well over half the students at School C (12/19) represented science and religion as separate entities, whereas no student in School B did so. (Schools C and D were attended by students from no particular faith background – although survey results from D suggested students were almost as likely to be Christian as to have no religious belief, see Section 7.1).

Students gave two main reasons for portraying science as larger than religion: it had more evidence, and was more plausible (Table 9.2).

> Jack: *I think science overwhelms religion too much because – they used to be probably about the same, they were more conflict, but now I think religion, not many people care anymore [...] after about the Victorian times, after that I think science just overwhelmed it*
> Lisa: *Yeah, [...] there's more evidence for science than the religion.* S/C3

The reverse was true for those who represented religion as bigger than science – for them, religion has more evidence and is more believable. In some cases the students were clearly influenced by their perceptions of the school subjects. For instance, the two in School A who portrayed religion encompassing science explained it was because they studied scientific knowledge in RE but did not touch on religious explanations in Science.

Some participants mentioned television programmes and books as providing a context for their conceptualisations of science and religion:

> Alan: *I read Angels and Demons and it's all to do with religion and science and two opposites and whatever, but in the end it worked out that a religious man actually switched, went to science, and he still kept his religion*. S/A5

These types of comments, together with the not insignificant proportion that cited the media as a main influence on their views about the origin of life (Section 7.5.1), demonstrates the importance the products of popular culture can have in determining students' thinking about these issues.

Table 9.2: Student representations of science and religion

		Inter-relationship of entities		
		separate	partial overlap	total overlap
Size of entities	religion bigger		• religion has more evidence • religion more plausible	• religion pre-empts science • God caused big bang • scope of school subjects (science covered in religion, not vice versa)
	equal size	• different viewpoints • different natures (proof vs belief) • some things make sense in both, some don't	• God used science • big bang then God • God then science • big bang in overlap • big bang not in overlap • related eg evolution • deal with same thing differently • science explains, religion causes • change one, change the other	• mix together
	science bigger	science has: • more evidence • facts • more plausible • religion is irrelevant	• science more plausible, religion enigma • God starts it, science takes over • religion peripheral • science has evidence/proof • Science more important than RE • new scientific theories but religious ones fixed	• all religion based on science • big bang essential

9.1.2 The inter-relationship typology

As a result of analysis of the drawings and explanations outlined in Section 9.1.1 and Table 9.2, a typology of the inter-relationship between science and religion has been developed. This became the focus of the discussion towards the end of the sessions, when participants had been given a chance to reflect on and develop their views. There was some ambiguity among a minority of students as to whether they were talking about religion and science within the school environment or in the wider world. Others were unable to disentangle the two environments. However, four main ways of characterising the relationship emerged: in parallel, interlinked, in tension, and incompatible.

Those for whom the two domains were "in parallel" saw science and religion as valid bodies of knowledge which operate alongside each other without interference. They dealt with different aspects of life, albeit sometimes different aspects of a common issue. In other words, there were occasional correspondences or bridging points between the two but one did not influence the other directly. For example, Suhana drew them as overlapping very slightly (Figure 9.3), but her explanation described them as different epistemologies:

> Suhana: *They ask different questions, they expect different answers ... science is more about evidence and proof and facts and what happens, and religion is more to do with God and why things happen and what's behind it.* S/B2

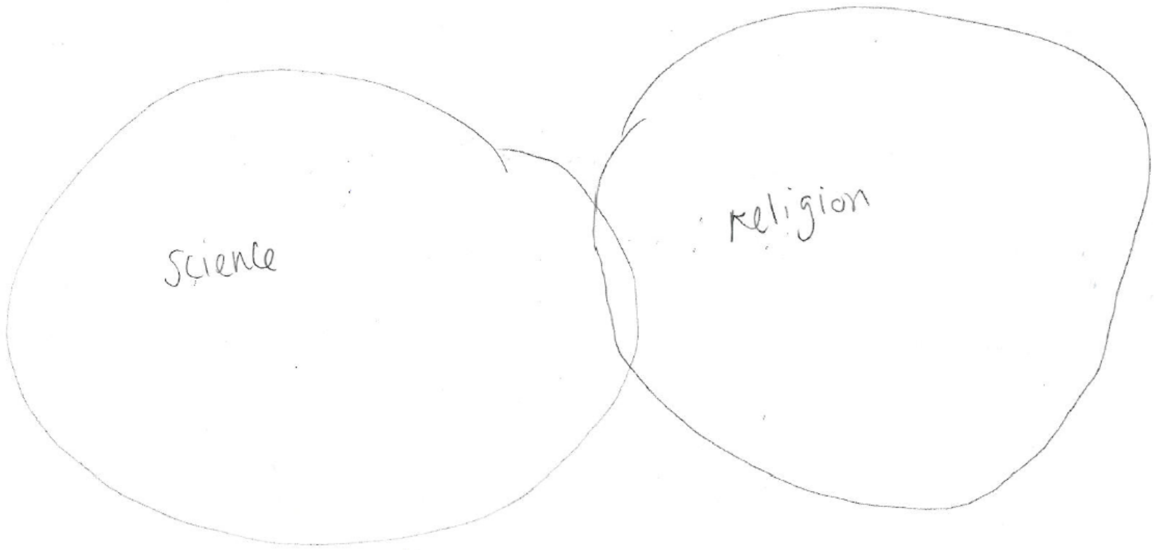
This position enables students to hold their religious beliefs comfortably alongside their acceptance of science. Because they tread separate paths, the two domains do not come into conflict. The category is very similar to independence as defined by Barbour (2000), and the idea of non-overlapping magesteria advocated by Gould (1999). The Head of Science at School B was the only teacher to fit here, describing science and religion as "incomparable systems" that do not overlap even though they explore common experiences.

Those who conceptualised the two as "interlinked" tended to have fairly strong religious commitments and gave examples of the mutually supportive nature of science and religion. For them, the two work together, with religion often perceived as being the original source or cause and science taking over. These two quotes are typical:

> Monshana: *You can see that there's a lot of theories that science has come up with now that's already written in the Qur'an ...* S/B4

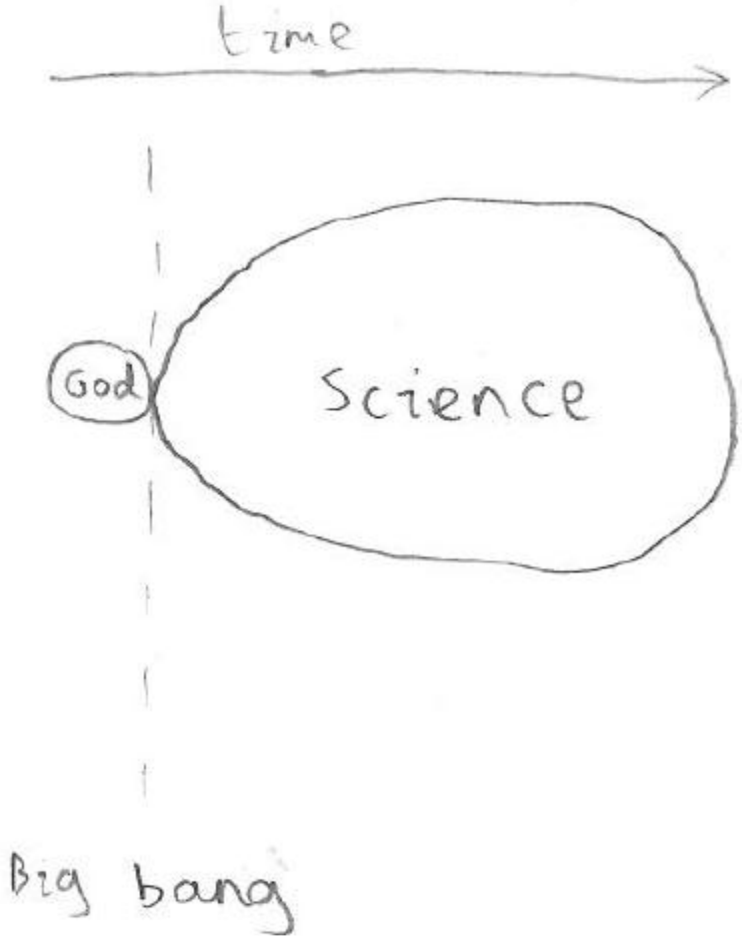
> *The big bang created the earth, but I think God created what was on it and everything that is on earth today evolved from creatures that God created.* S/A/q5

Figure 9.3: Suhana's drawing



Tom in School A conceptualised the relationship as shown in Figure 9.4. In the drawing, he has incorporated a time axis and the moment of the big bang.

Figure 9.4: Tom's drawing



Tom interpreted religion as being synonymous with God and he explained his drawing as follows:

> Tom: *I think they're linked so – God did do something but I think science also takes a part on it. So God can start it off and then science can take it over and every time it's God starting then science doing it, so God just sort of…*
>
> Alan: *Pushes the first domino*
>
> Tom: *Yeah, pushes something.* S/A5

Several of the teachers fell into this category, including the Head of Science at School A, who felt the two enhanced each other:

> Phil: *I think they're mutually supportive of each other, in fact the more I study about science the more I know that my faith must be right because I feel the science emphasises that. But of course from the faith point of view the study of science seems a very natural thing, because it seems an exploration of the wonders of the God I believe in. I don't think there's any conflict.* T/Sci/A

Linking this back to Barbour's taxonomy, it corresponds to a combination of dialogue and integration. With reference to the other models considered in Section 2.3, it is perhaps closest to the same-worlds position described by Shermer (2006): science and religion share a common field of inquiry and their conclusions can reinforce each other.

A third group also thought that science and religion overlapped, but they differed from the interlinked group because they perceived the relationship as "in tension" rather than trouble-free. They were aware of a number of contradictions which made it difficult for them to reconcile the two.

> Jessica: *I think they're separate but together.*
> Researcher: *OK, you'll need to say a bit more - separate but together?*
> Jessica: *Well, some things don't add up on the science side to the religious side but then some things do*
> Researcher: *Any particular thing you're thinking of there, can you give me an example?*
> Jessica: *Like, how you were born and how the religious view they say you were born at first. I can't explain it but…*
> Gayle: *God created you but you came out of your mum (laughs).* S/A4

This theme of "separate but together" was also touched on by the Head of RE at School A. For him, there was a degree of separation that was only breached under certain conditions, when the conjectures of one discipline had implications for the other. Under these circumstances, he could recognise that the two worlds might be in tension:

> Rick: *I think the RE teacher or the RE student is looking at the question of why is it that we came to exist whereas within the science the focus is on how. And I suppose you could separate them but maybe the separation would be to the disadvantage of the student, in so far as in looking at why we exist it may be necessary to engage with the how question. It might not, but it might [...] in so far as if the answer to how is a divine power creating the universe in seven days and a universe of six and a half thousand years old or however we want to age it, then the how and the why are connected. And vice versa. If we have a scientific*

explanation for the origin of the universe which leaves no scope for the existence or the role of a higher power, then the two are connected in that sense. So to say that they are completely separate I think is to miss that part of the question. T/RE/A

It was extremely common for research participants to use the term "sides" when referring to science and religion. This indicated a default position of seeing them as alternatives that could be in tension to at least some degree, for instance:

Callum: ... *Cos you go to church*
Sara: *Yeah*
Callum: *And I've never been to church except when you're in junior schools [...] so [Sara] knows the other side of it but I kind of only know the scientific side*
Sara: *I know of the other side, so it's like it could be this or it could be that.* S/C

Despite being a stance commonly identified in this research, "in tension" has no direct equivalent in Barbour's taxonomy (Barbour, 2000). His category of "conflict" was the only one which described science and religion as not being in harmony. In his model, this was because one or other had no legitimacy, whereas here both are recognised as valid domains of knowledge albeit difficult if not impossible to reconcile. In other words, they can enter into dialogue but it might sometimes be a very uneasy exchange.

The fourth group perceived a contradiction between science and religion to such an extent that they were judged incompatible. Unlike those in the 'in tension' category, they were not involved in a struggle to accept both paradigms: their position was very emphatically that only one had any authenticity. For some this was science:

Amy: *I don't think there's any proof that God made the universe and the world and whatever but there's proof with science how it formed and stuff. I just think religion is something that people believe in.* S/A4

In other cases it was religion:

Darren: *I just believe the Christian way and that's it, yeah.* S/D1

This is similar to Barbour's category of conflict (Barbour, 2000), but to call it "in conflict" would be misleading. I would argue that, as one body of knowledge is dismissed as worthless, it cannot be in conflict with the other. Conflict is possible only if both positions are recognised as valid.

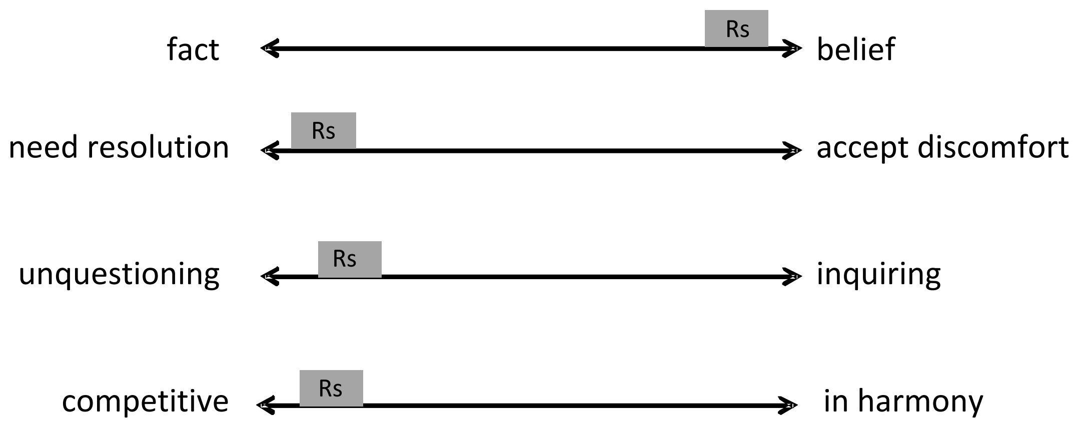
9.2 A typology of engagement

Another layer of difference became apparent during analysis and this related to how willing research participants were to become engaged in the inter-relationship between science and religion (as exemplified by the origin of life topic). They divided into categories depending on both the nature and amount of involvement they were prepared to have. Participants could be assigned to one of five forms of engagement: Resistors, Confused, Reconciled, Explorers and Rejectors. It is important to recognise the groups do not represent a hierarchy – it should not be assumed that the aim is to shift an individual from being a Resistor to an Explorer, for instance.

Each group has been profiled according to a slight adaptation of the four dimensions used to define the characteristics of Science and RE (see Chapter 8). This gives an indication of whether their preferred knowledge base is belief-based or fact-based; how flexible members of each group are in terms of tolerance of uncertainty and open-mindedness; and whether they conceptualise religion and science as being in conflict or harmony.

9.2.1 Resistors

Figure 9.5: Resistors



Resistors value belief-based knowledge above fact. They consider that scientific and religious views cannot or should not be reconciled:

> Rajhana: *[In our school] there's only so many people who aren't Muslims and for us to learn about something which we don't believe in ... we follow our faith for a reason, we shouldn't have to question.* S/B1

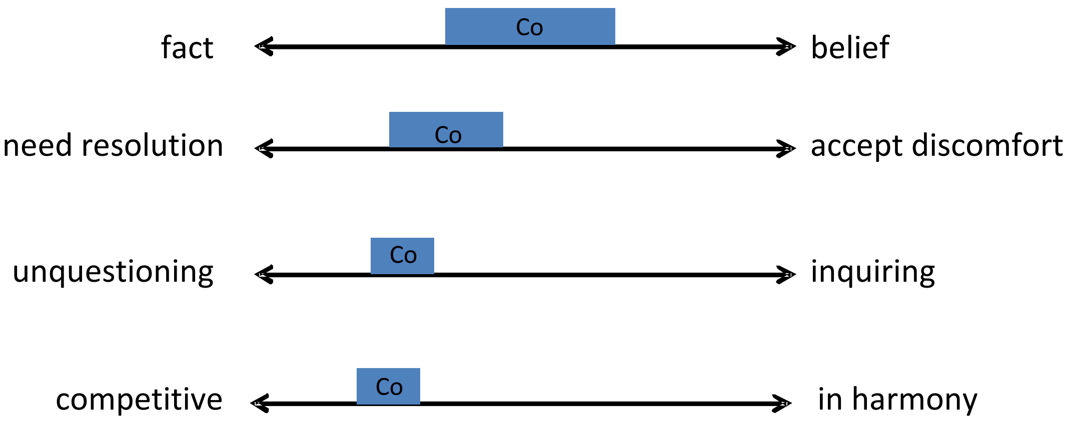
During the Science lesson observation at School B, some of these students were vociferous in their resentment of the approach which encouraged them to tackle science and religion alongside each other. For instance, Asma beckoned me over to make sure I was aware of her unwavering belief in Islam. She was adamant that science had no proof or explanatory powers, giving as an example the genocide in Rwanda. She and a friend went on to have this exchange about the lesson objective of exploring how the universe began:

> Asma: *Why do we have to know?*
>
> Zafeera: *It just confuses us*
>
> Asma: *Because we have religious points of view in our head and we have to look at science and it gets all muddled up.*

Several of the Muslim students were in this camp but, importantly, not all of them. Whereas the students who fell into this category did so because of their adherence to a religious epistemology, the one teacher who could be labelled a resistor was totally convinced of the superiority of scientific explanations. Isobel showed no inclination to question her own stance, and by her own admission she was keen to close down any debates with her students. It may seem counter-intuitive to place her in a category that prefers a belief-based knowledge system. However, her respect for scientific authority evokes the definition of scientism by Japanese science educator Ogawa (1999) as an "unconditional *belief* in science" (p5) [my emphasis]. Although none of the students seemed to share Isobel's position, it is possible that the social nature of the focus group prevented them expressing fiercely rejectionist views of religion for fear of offending other participants or the researcher.

9.2.2 Confused

<u>Figure 9.6: Confused</u>



Examples of the Confused were found across the different schools. They fell into two categories. Some students are consciously confused and making uneasy compromises. They have spent time considering the matter but cannot reconcile their religious beliefs with the scientific evidence available:

> Lee: *I don't really know what to believe because the science is telling you one thing and the RE's telling you another. I was raised up with the RE but the science is more logical so I just kind of bottle out and pretend they're both right.* S/A

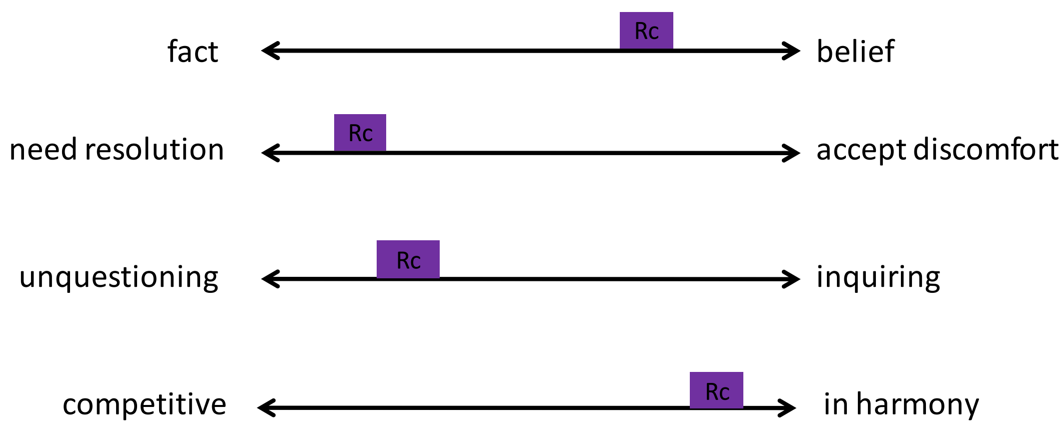
Other students seem to be confused more because they have not given the issue much thought rather than having a fundamental problem bringing together religious and scientific standpoints. They may remain confused after further consideration, but at the time of the research had not yet managed to think it through very logically, if at all:

> Shajnah: *I think the big bang theory's based more on fact and religious views – yeah, to us basically [religious view is] fact because we believe it and - I think religious views are more based on faith and teachings rather than facts.* S/B1

The Confused are often torn between belief- and fact-based knowledge systems. They see science and religion as being in competition, and they find it difficult to be sufficiently open-minded to achieve the resolution they desire.

9.2.3 Reconciled

Figure 9.7: Reconciled



The Reconciled have come to some accommodation between their religious views and the scientific outlook allowing them to accept them both:

> Yasmin: *We also debated the big bang theory in RE as well and we felt ... in order for the big bang to have happened there must have been a superior being to have caused it.* S/B4

They tend to give precedence to belief over fact. In their worldview, science and religion are in harmony. The sixth form helper in the School B lesson observation remonstrated with those students who were complaining about having to address questions about origins by telling them that studying science could make their religion stronger, and confirm their belief. In later conversation, she told me that in her opinion there was a lot of science in Islam and the two could work "*hand in hand*". Pressed on evolution, she conceded that animal species might be able to change but only if God guided the process.

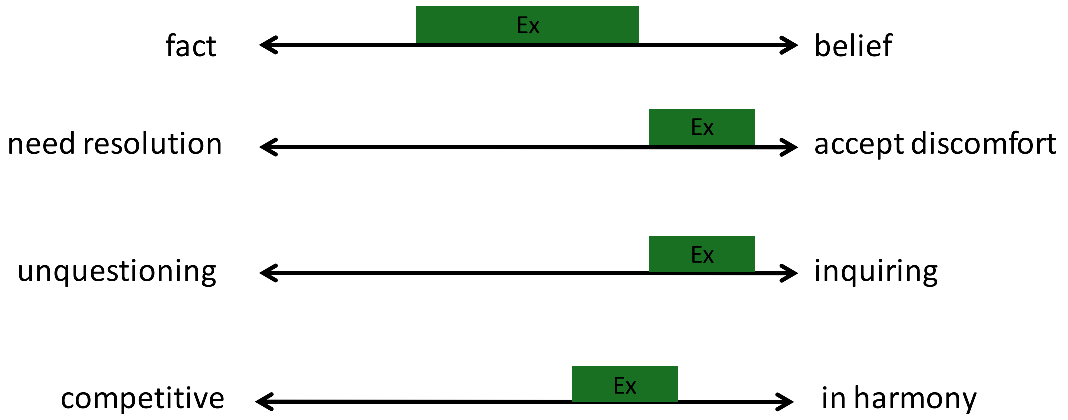
The Reconciled are looking for resolution and are not keen to question, or alternatively they have passed through the inquiring stage to reach their current state of understanding. They will engage but on their own terms. The key question is: how genuine is the accommodation? Is it something they embrace or a grudging compromise? Triangulation of data from the student questionnaire and focus groups in School B shows that, whereas no survey respondent suggested life had come into being via a combination of God and science (Section 7.3), this was a not uncommon proposition in the focus groups. One hypothesis is that students are more honest in the survey responses, where there is no intermediary, and more likely to recite a convenient compromise (that they think might be more acceptable to the researcher) in the focus groups. The implication would be that some members of the Reconciled group are really Resistors, or maybe Confused.

Most of the participating teachers from the case schools would come within the Reconciled category. They had obviously given the issue considerable thought, perhaps as Explorers, and were now satisfied that they had reached a comfortable position. This does not, of course, mean they have reached the same conclusions. Phil and Dean both acknowledged some role for a divine being in the origins of the universe and life, but the detail was radically different. Phil, head of Science at School A, described evolution as "*God's way of applying his creation. You know, he wants humans, well that's how he did it.".* This would not fit comfortably with the mechanism of natural selection, dependent as it is on random mutations and differential survival rates. In contrast, Dean's opinion was:

> Dean: *I think for us to have what we have now, it was a chance in a million million probably for life to form, and I think there must have been some divine spark, but I just see the Bible story as an explanation rather than the explanation. I think it's human ego to say that "this is the real story" ...* T/RE/D

9.2.4 Explorers

Figure 9.8: Explorers



Explorers enjoy the challenge of fitting together religious and scientific viewpoints, which they see as more likely to be harmonious than competitive. As shown by the quote from Sumaya below, they might even be willing to adjust their worldview if sufficient evidence is offered. They are curious and willing to engage openly with the topic, as well as being flexible in their outlook:

> Nazia: *Cos we learn about religion and science together on a daily basis we really have the choice to decide if there's a conflict or not.* S/B4

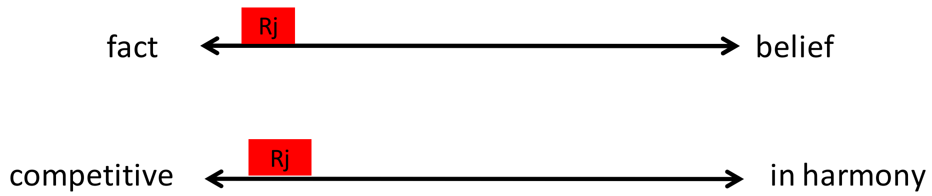
> Sumaya: *The big bang theory's made such a huge impact and people are talking about it more ... once we start learning about everything we start seeing things in a different way and it might change our perspective.* S/B1

By their very nature, Explorers are not wedded to an epistemology of either fact or belief, but are constantly weighing up the two forms of knowledge. Even if, as has been stressed already, the typology is not a hierarchy, Explorers could be characterised as having more highly developed critical thinking skills than most students in the other categories. Sinatra et al. (2003) concluded that those who were more inclined to be open-minded and reflective were more accepting of human evolution, although there was no correlation with animal evolution. In their study of Turkish pre-service biology teachers, Deniz et al. (2008) found that thinking dispositions explained more of the variance in acceptance of evolution than either students' understanding or the educational level of their parents, but its contribution was still fairly modest.

Representatives of this group were not very common in the research.

9.2.5 Rejectors

Figure 9.9: Rejectors



Rejectors did not engage with the topic as conceptualised by discussion of how life on earth came into being. For them, it was not an important question. This made it impossible to chart the dimensions related to tolerance of uncertainty or open-mindedness. Rejectors tended to prefer factual explanations and to see science and religion as competitive or conflicting. There were two main reasons for rejecting engagement with the origins topic - either they thought it could not be answered, or it was simply not relevant:

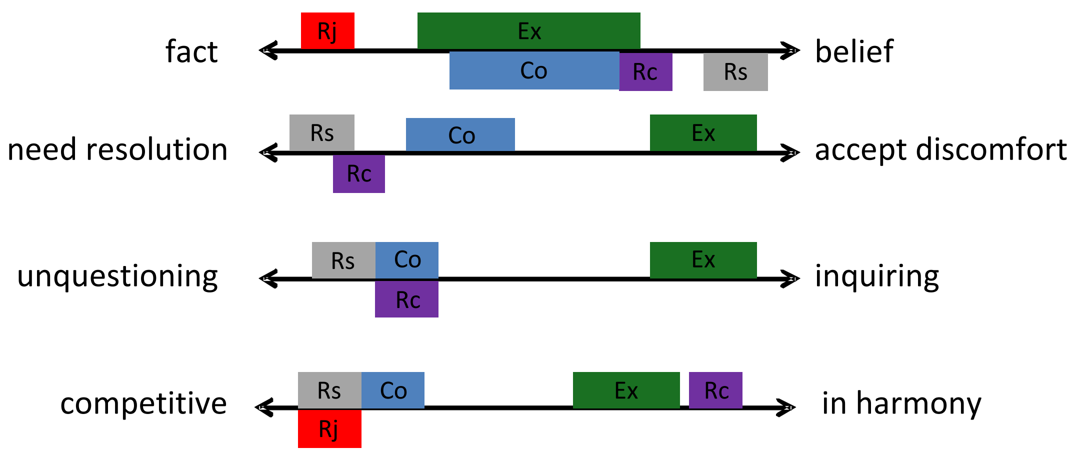
> Brett: *It's not even that important because we've already been created so what's the point in worrying about the past.* S/A1
>
> *I don't really think about the life on earth came into being as there are many different reasons that people have considered and therefore I think that it will never be possible to discover what happened. I also think that it is pointless trying to find out because we won't achieve anything from it.* S/D/q3

Many of the Science teachers in the focus group at School D would fall into this category. They exuded a sense of puzzlement as to why the research was being conducted, and afterwards the member of staff who was acting as gatekeeper – with whom I had already exchanged several explanatory emails as well as holding a preliminary meeting – asked again, "*Why are you doing this? What are you hoping to find out?*". Science teachers at the other schools, who had received a similar level of briefing, showed far more appreciation of the topic as an issue worthy of investigation. This was particularly evident in School B, where moreover only one student (a survey respondent with no religious belief) was classified as a Rejector.

9.2.6 Summary of engagement types

The complete model with all the engagement types mapped on it is shown in Figure 9.10. It demonstrates that, for three of the four dimensions, Resistors map to one extreme of the scale, and Explorers to the other.

Figure 9.10: All engagement types



Key
Co = Confused (undecided between belief/evidence, or not considered previously)
Ex = Explorer (openly engage with topic)
Rc = Reconciled (accommodate religious beliefs and scientific evidence)
Rj = Rejectors (not engaged with research topic)
Rs = Resistors (refuse to engage with one concept, usually the scientific evidence)

It was stated at the beginning of this section that the typology should not be interpreted as a hierarchy, with some categories preferable to others. The exception to this is the "Confused" category, which might be regarded as less desirable. These students (especially those who are consciously confused) risk feeling troubled and may need teacher support to work through and clarify their position. Those who hold the opinion that biology education should prioritise student acceptance of evolution (Section 5.1.2) might argue that the model is hierarchical. For them, the aim would be to shift students from Resistors and Confused through an exploration stage to be genuinely Reconciled – reconciled, in accordance with their ideology, to the scientific paradigm. Amongst those for whom understanding rather than acceptance is the goal, the priorities would be elucidation for the Confused and ensuring that those Resistors who adhere to a religious perspective at least appreciate the scientific one.

Teaching of this topic has to fit within the context of the current ethos of secondary science education in England. There is an understandable tendency for Science teachers to shape their practice according to what they think will bring their students exam success (Millar, 2011; Collins, Reiss, & Stobart, 2010; Wellcome Trust, 2011). This “playing safe” by emphasising certain aspects of learning and development might mean acceptance of the discomfort and inquiry ends of the above dimensions, for instance, are not actively encouraged in the classroom. As Burton (2008) noted, ‘‘If the fundamental thrust of education is ‘being correct’ rather than acquiring a thoughtful awareness of ambiguities, inconsistencies, and underlying paradoxes, it is easy to see how the brain reward systems might be molded to prefer certainty over open-mindedness’’ (p. 99).

9.3 Vignettes

To help exemplify the models – both how they arose from the data and how they have been applied to individual participants – it is instructive to examine “lived examples”. The following sub-sections provide more detail about two particular students, and how they fit into the typologies outlined in this chapter.

9.3.1 “There’s so many different answers”

Nazia, School B
Science and religion inter-relationship: Interlinked
Engagement typology: Reconciled/Explorer

Nazia is a Muslim girl in the top science set at School B. She was interviewed along with two friends and tended to dominate the discussion, acting as their spokesperson on a number of occasions. She regarded herself as quite daring and radical in her opinions, especially when she critiqued her fellow Muslims. It is worth noting that this focus group (unavoidably) took place in a room where three other students were undertaking private study. Originally, these girls were due to form the following focus group – however, they subsequently declined and their body language during the discussion with Nazia and her friends suggested that they were uncomfortable with some of the views they could hear being expressed.

Nazia said she only discussed the origin of life in the school environment (“*We don’t actually think about stuff like that outside school*”). She acknowledged the importance of science to everyday life, but felt that a “great mind” was also at work:

> *A lot of people I guess think like that because when science can’t prove something we’re – every day, everything we do every day is based on science, even if we walk it’s science, gravity’s keeping us on the floor, it’s science. It’s just simple*

> *things that we think science cannot prove completely - or has no theory on – them kind of things we just think ok, there's a great mind is controlling that kind of thing.*

Although this seems to be a relatively unsophisticated "God-of-the-gaps" explanation, where the "great mind" will gradually become responsible for fewer phenomena as science is able to explain more, Nazia appeared to be prepared to interrogate her beliefs at a deeper level. This willingness to question moves her from the Reconciled towards the Explorer typology:

> *... I think there are a lot of stereotypes about oh my God, science is trying to take over religion, is trying to push religion out of the way, but I think for us we think – there are really controversial topics like is it science that creates you or is it God, they're the ones that you have to be able to feel the want to challenge it. And obviously some people are quite scared to think that way and maybe it's conflicting with their religion but what helps is that other things like the biology of it and how the human body can be... It can be explored more in science whereas religion can provide different explanation. That's what we enjoy about it, there's so many different answers and you get to choose which one you want to believe in.*

She was the only student in the research who mentioned experiencing a synergy between Science and RE lessons:

> *[...] when we're in Science although we're learning science we can pull our knowledge, because we do learn science in RE, we can pull our knowledge of RE science into our Science lesson and vice versa, which helps us a lot because then we have a greater understanding of our own ideas about religion and science fitting together.*

Furthermore, Nazia conceptualised science and religion as intimately related, a situation which she represented in her drawing (see Figure 9.11 overleaf) as two circles overlapping within a larger, encompassing circle:

> *My [drawing] is basically religion and science both merge together but I think they come under the whole – for me, the bigger outer circle represents life and everything else and it shows that in life there is religion and science mixed together. That's what it is for me.*

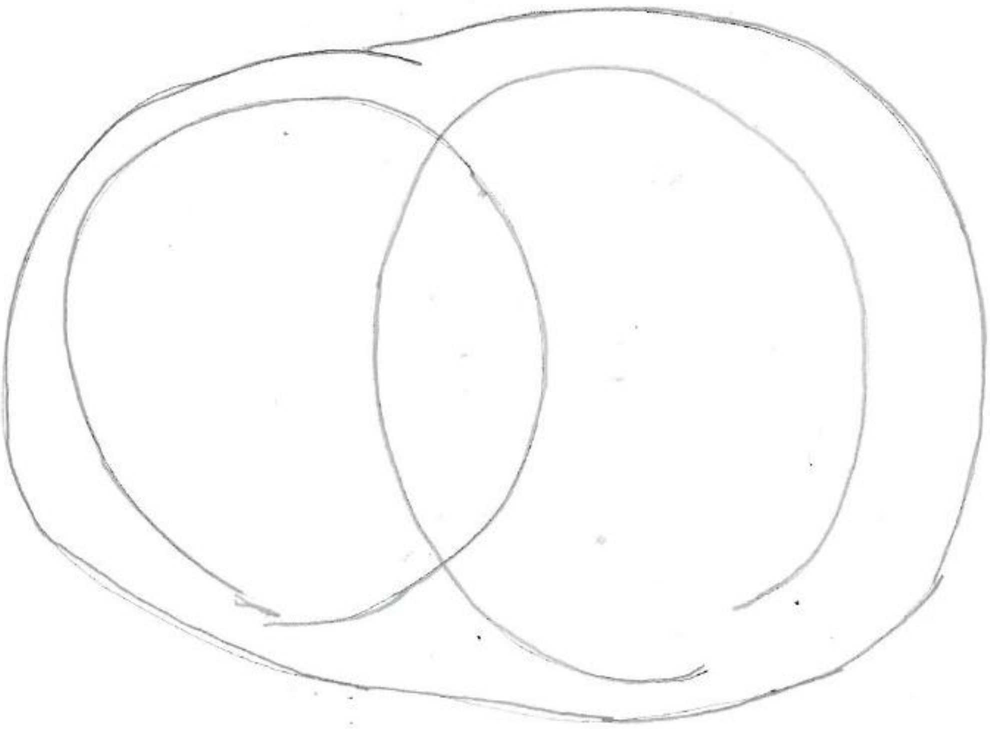
She felt that science and religion were not always in agreement and referred to them being in conflict over the centuries. However, she differentiated herself from those "religious people" who might think that science was trying to replace God portraying herself instead as someone who was willing to address the contradictions:

> *[...] say we originated from – we evolved from apes, then for example in Islam it states that every being is the child of Adam, how is it that Adam can exist, he was a human, yet we evolved from apes, there's that question we ask each other and we try and find answers to – so yeah, we conflict with our own ideas a bit.*

She prided herself and her peers on being prepared to question the received religious wisdom in a way older generations might find impossible:

> *And because of the world we've created now it's more modern and we think both sides rather than back then people had one view and focused on that, now we can think around it.*

Figure 9.11: Nazia's drawing



9.3.2 "We had God from Rosie"

Rosie, School C
Science and religion inter-relationship: In tension
Engagement typology: Confused

Rosie, a Mormon, attends School C. Her propensity to challenge ideas in the science classroom from the perspective of her religious beliefs, particularly her refusal to accept the existence of dinosaurs, seems to have had considerable impact within her class. Her interventions were mentioned by several other research participants, as exemplified in this exchange:

> Researcher*: Any other things you covered, explanations of how life on earth came into being? Not necessarily scientific but any other kind of explanations?*
>
> Lisa: *We had God from Rosie*
>
> Researcher*: God?*
>
> Lisa: *How God gave us every creature from Rosie*
>
> Jack: *Yeah*
>
> Lisa: *She says that God's created everything – without the dinosaurs*
>
> Jack: *Yeah, it's quite funny the arguments that come out (laughter)*
>
> Lisa: *Yeah, arguments between her and Miss.* S/C3

Rosie had chosen to explore her contention that dinosaurs had never existed for her GCSE coursework. Isobel, her teacher, admitted that – although she encouraged students to write their case studies on topics that interested them personally – she had tried (without success) to persuade Rosie against this particular line of enquiry. She was worried that, lacking any scientific evidence to support her case, it would be impossible for Rosie to achieve reasonable marks.

Fellow pupils tended to categorise Rosie as someone who rejected science in favour of her religious beliefs, whereas Isobel was not sure whether Rosie genuinely adhered to a fundamentalist religious standpoint or was just "attention seeking". The reality seemed rather more complex. In terms of the relationship between science and religion, Rosie perceived them to be "in tension", aware of a number of contradictions that made it difficult for her to bring the two together. However, her religion did not automatically over-ride science, and when probed about the views on the origin of life among people at her church, she replied:

> *They're really biased, they have their religion belief and anything that's to do with evolution they throw back and they say it never happened, evolution it's just totally wrong, and so – from the school, we learn mostly about the scientific way rather than religion, like I'm stuck in the middle so I get evolution from school and religion from church and I'm able to get both sides of the argument.*

Prompted further about how she came to terms with the differing standpoints, her response showed an element of frustration when she was unable to reconcile them:

> *Well, it's good because you think of God and how he would have made it and you think of particles going together and that makes sense, but then you think of the fact that, how do the particles come together and you think of God and it just – they bounce off each other. Some things can really clash and they just don't make sense.*

Rosie was unable to support her rejection of evolution with any evidence or logical argument, although she was unyielding in her rejection of the theory:

> Rosie: *I've a strong belief in God and I believe that God made earth.*
>
> Researcher: *In what way? Because you said it might be that God caused the particles..*
>
> Rosie: *Yeah, I think that God caused the world to make itself if you know what I mean. So he didn't sit down and say hey, let's put this there and put this there, he planned it all to go and form together.*
>
> Researcher: *So would you say that evolution [...], would you say that that has happened, that God caused it to happen, or would you not know, or?*
>
> Rosie: *I don't believe in evolution. I believe in God.*

She was sceptical about the fossil record ("*the evidence is fossils but it could be humans interpreting the fossils wrong*") and, in relation to her proposition about dinosaurs:

> *Yeah, it's like nobody has real evidence, I know there's bones and fossils and things like that, but how do you know they're just not animals, how do you know they were dinosaurs, actual animals – how do you know that you didn't just put a*

> *load of bones together to make something that you want to make. I think people rather want them to be real than know that they are real.*

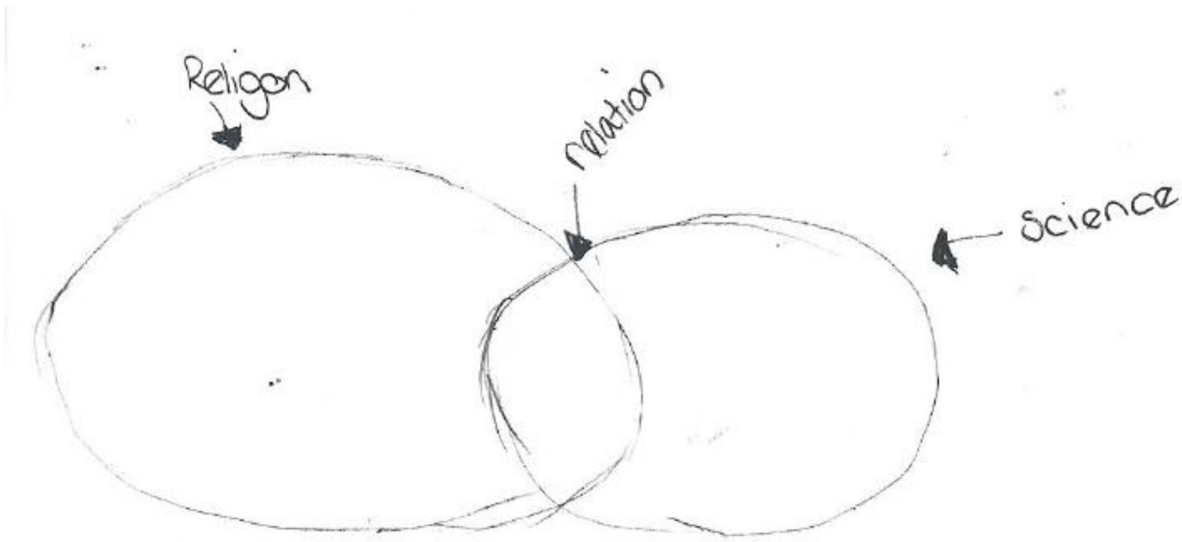
Although, in terms of the engagement typology, she has some elements of the Resistor, her willingness to engage in some parts of the debate would potentially shift her into the Explorer camp. It seems that the dogmatic approach of her religious community, together with powerful rebuttals from her teacher (*"[Isobel] has a really really strong view on evolution. We normally just sit there arguing over it..."*), have combined to make her one of the "Confused". For instance, in respect of evolution and species extinction she made the following contradictory statement:

> *I don't believe in evolution but I think there's a possibility that the dinosaurs could have evolved into things that are today, but I think that's the only possibility that they could ever have existed.*

When Rosie summed up her attitude to science and religion (Figure 9.12), she explained her schematic as follows:

> *I think religion's bigger because to me it makes more sense. Rather than a load of particles going together and that's how it all started. With science there are like some fossils of evolution, but I feel strongly that fossils are just imprints in rocks. I don't really think they mean anything, and if they do mean things that we're reading them differently so we're getting the wrong interpretations for them. There are some relations in it, like God making the particles that form together [...] and stuff like that with evolution, but I think overall religion – the religion side of it makes more sense to me.*

Figure 9.12: Rosie's drawing

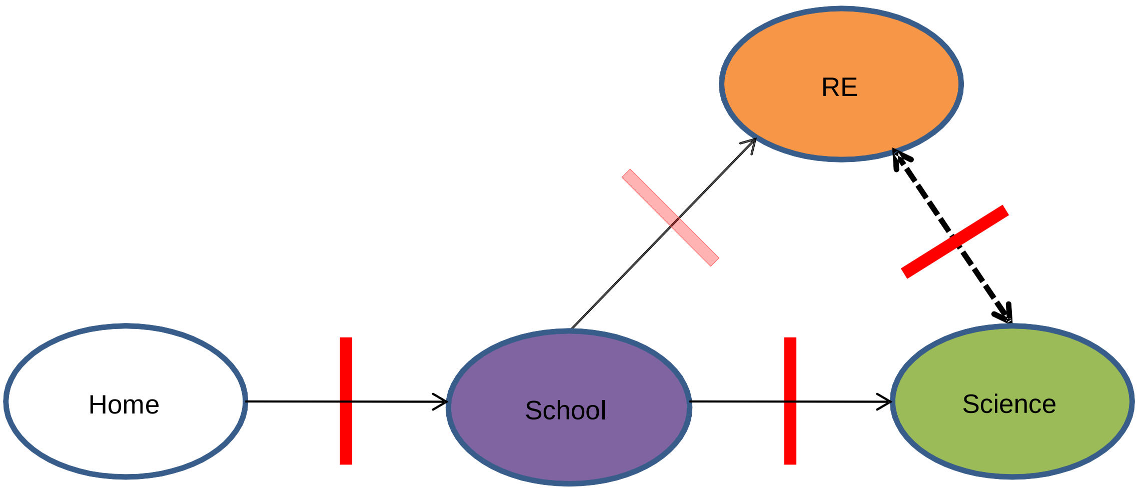


9.4 Engagement in the context of border crossings

In their model of multiple worlds, Phelan et al. (1991) treat school as a single entity in terms of its norms, values, expectations and actions (Section 5.3.2). Subsequent work, in focusing on science within the world of school, recognises that the picture is rather more complex (Aikenhead, 1997; Costa, 1995). Chapter 8 showed that school Science and RE can vary enormously from each other in several ways, including their delivery and theoretical underpinning. Students who struggle to accept scientific views of the origin of life not only have to deal with possible discontinuities between their home culture and that of school, but also with potentially contradictory messages and modes of delivery emerging from the Science and RE classroom. They must deal with the nuanced layers of home, school, Science and RE. Students access Science or RE through the filter of the school environment, then – for those who make the link between the two subjects – there is a further, inter-disciplinary, border to navigate.

This is illustrated in Figure 9.13, where the border crossings are represented by the short, solid black lines. Firstly, the student has to successfully pass from the home to the school environment. Then they have to negotiate their entry into the RE and the Science classrooms. The findings in this chapter suggest that, with regard to the origin of life, the border crossing that requires particularly careful navigation is the one into school Science. For most students, the one into RE is more porous (indicated by its paler colouration in the diagram).

Figure 9.13: Border crossings into school Science and RE



Some of those who engage with the two subjects will recognise a link between them as exemplified by shared topic matter such as the origin of life. This has been drawn as a dashed line (because not all students are aware of the link, nor will they all choose to engage with it). Again, there is a border to be negotiated and it can be crossed in either direction (hence the double-headed arrow) whereas the other borders are primarily one-way passages (home to school; school to school science or school RE).

Attempts to reconcile two potentially very different ways of covering the same topic can cause considerable confusion. Parallels can be drawn with work cited by Whitty (2010), who had previously studied the difficulties of teaching themes (such as health education) that permeated different areas of the National Curriculum (including science):

> What counted as legitimate talk varied from subject to subject, making the cross-curricular treatment of the same issue extremely problematic in that what counted as appropriate talk about an issue in one subject differed from that in another. For some pupils, the consequent ambiguity led on occasions to the transgression of the rules applicable to particular subjects. (p. 40)

Costa (1995) used the relationship between students' academic success and their ease of transition between the home and school Science environments to develop a categorisation of students (Section 5.3.2). Her model is underpinned by an assumption that the degree of cultural continuity between home and school Science, and students' ability to negotiate any gaps, is directly relevant to their success in the subject. Mapping the engagement typologies to Costa's model can give some tentative indications about the implications for students' performance in science. However, this should be treated with considerable caution, not least because a tiny (albeit important) part of the Science curriculum (the origins of life and the universe) is being used as a proxy for the ease of their transitions into the totality of school Science (Table 9.3).

Table 9.3: Typologies mapped to Costa's model

Typology	Ease of transitions into school science	Home vs Science culture
Resistors (refuse to engage with one concept, usually the scientific evidence)	impossible	discordant
Confused (undecided between belief/evidence, or not considered previously)	hazardous	inconsistent
Reconciled (accommodate religious beliefs and scientific evidence)	smooth/manageable	congruent/ inconsistent
Explorers (openly engage with topic)	manageable	inconsistent
Rejectors (not engaged with research topic)	smooth	congruent

Resistors have similarities with Costa's "Outsiders", probably finding school culture as a whole alienating, and not simply aspects of Science. Costa found they tended to fail at school science because they were so distanced from it – similarly, it can be hypothesised that Resistors might fail to relate to at least the origins aspects of Science because of their disengagement. Their preference for belief-based systems and their view of the relations between science and religion as antagonistic, combined with the desire for clear positions that are not open to doubt, suggests they would resist or even resent attempts to draw them in through discussion and debate.

The Confused have similarities with Costa's "I don't know" students. Costa found that such students, because they were not actively hostile to science, achieved satisfactorily. They were motivated by fear of failure rather than inherent interest in the subject. In the taxonomy proposed here, those who are confused have personal backgrounds that do not sit comfortably with the scientific orthodoxy. Up until now, they have not engaged to a sufficient level to resolve the discontinuity – either because their attempts have failed, or because they have not tried. Since they see science as being in competition with religion, the risk is that they will be discouraged from studying Science at school.

Reconciled students could represent Costa's "Potential scientists". For them, home and Science cultures are congruent because they perceive science and religion to be in harmony, making transitions straightforward. Others may have found the transition more challenging although still achievable, and as with Costa's "Other smart kids" the personal relevance of science is limited, so although they are not philosophically opposed to engaging with it, they see no reason to do so.

Explorers, as the only group who – despite discord between cultures - relish inquiry and recognise that the outcome will not always be a concrete conclusion, do not fall easily into any of Costa's categories. They do not meet the criteria of "Potential scientists" because their transitions are not smooth nor their home culture congruent with school Science. Yet their enthusiasm for the subject excludes them from being "I don't know" or "Outsiders", and their lack of alienation from school generally disqualifies them from "Inside outsider" status. Although their manageable transitions and inconsistent cultures find parallels in the "Other smart kids" group, unlike them they want to engage with science. Yet nor does Aikenhead's additional category of "I want to know" students (Aikenhead, 2001) match their characteristics, because their understanding is not necessarily limited to being "modest yet effective" (p. 186). Explorers, it seems, sit outside Costa's framework.

Although Rejectors refused to engage with the origin of life debate as exemplified by this research, they seemed to have no issues accepting a scientific viewpoint and as such, fitted Costa's "Potential scientists" category.

9.5 Summary

This chapter proposes two complementary models based on the data emerging from the research. One is a framework for describing interpretations of the inter-relationship between science and religion. It consists of four categories: in parallel (science and religion are totally separate apart from occasional correspondences); interlinked (the two overlap and are mutually supportive); in tension (the two are linked but in an uneasy, often conflicting relationship); and incompatible (one or other realm has no validity).This model resonates with the taxonomy suggested by Barbour (1990), although it merges the categories that treat science and religion as mutually supportive (Barbour's dialogue and integration) and puts forward an additional category of "in tension" (where links between the two are recognised but are characterised by friction rather than synergy).

The second model is a typology of engagement, based on the level of willingness to engage with the science/religion interface as represented by the origin of life topic. The classification system has five types: Resistors, who resent being expected to engage (usually because of their strong religious beliefs); Confused, who have not yet worked out a logical stance on the issue; Reconciled, who manage to accommodate both science and religion; Explorers, who are curious and enthusiastic to engage; and Rejectors, who are indifferent. This framework is consonant with the model devised by Costa (1995) and augmented by Aikenhead (2001), but identifies a further group comprising students who are enthusiastic about science and achieve managed transitions into the school subject despite incongruent home cultures.

10. Conclusion

This chapter summarises how the study has answered the four original research questions before considering the pedagogic, curricular and policy implications. This is followed by a critique of the study and then suggestions are made about possible next steps. It begins with a consideration of new insights that have arisen from the research.

10.1 Contribution to knowledge

As a result of this study, two conceptual frameworks have been postulated. One relates to the main properties by which a school subject can be profiled; the other to the willingness of students (and teachers) to engage with a specific topic. In this study, the school subjects were Science and RE as exemplified through the topic of the origin of life. It is argued that the frameworks could be applied more widely.

Before considering the models in more detail, it is worth giving an overview of how science and religion were seen to inter-relate (the inter-relationship typology) as this had an impact on how individuals were positioned within the frameworks. Four main views on the relationship between science and religion are mapped out, and these have been examined in relation to Barbour's classification (Barbour, 1990; Section 2.3).

The first view is that the two domains are in parallel – both valid but covering different aspects of life so operating without interfering with each other. This is similar to Barbour's independence. A second view deems them to be interlinked and mutually supportive (a combination of Barbour's dialogue and integration). The third is that the domains are in tension with each other – both are valid but sometimes contradict each other. This has no real equivalent in the Barbour model. The final position is that of incompatibility where only one domain is judged to have any validity. This is how Barbour defines his category of conflict, although I would argue that it is a misnomer because they cannot conflict if one is dismissed as baseless. To summarise, the study found some similarities with Barbour's taxonomy but also some important differences.

To at least some extent, the conceptualisation of the relationship between science and religion acted as a lens through which participants related to school Science and RE. Some found it more difficult than others to disentangle the school subjects from the domains. Four dimensions have been identified as key to characterising the school disciplines of Science and RE. The first is the foundation of its knowledge base: whether it is underpinned more by fact or by belief. Secondly, how tolerant it is of uncertainty: is doubt accommodated or does it demand certainty? Thirdly, the level of open-mindedness: whether it encourages a questioning approach or is closed to discussion. The final dimension looks at the relationship between the two subjects: whether Science and RE operate in a spirit of co-operation or disharmony.

The first three of these dimensions could be applied to school subjects other than the two examined here. The fourth dimension, which looks at inter-relationships, could have an important role when cross-curricular activity is being considered. Mapping students' views – for instance, how they conceptualise the relationship between Science and English – could inform the best approach to take with a proposed collaboration.

The second proposed framework focuses on propensity to engage with the topic. The typology is based on a five-way categorisation. Explorers were identified as those who are prepared to become involved with the topic and maybe change their worldview if faced with convincing and conflicting evidence. The Reconciled experience no conflict between scientific explanations and their religious views, meaning that (at least superficially) it is not a problematic area of engagement for them. The Confused are either incapable of resolving perceived friction between their religious views and scientific interpretations, or they hold no cogent position on the matter. Engagement for them would be useful, although levels of willingness to get involved might vary. Resistors are very defensive, entirely wedded to their belief system and unwilling to consider there might be a different perspective. The fifth category, the Rejectors, dismiss the topic of how life on earth came into being as unimportant and consequently failed to engage with this aspect of the research.

Although the study was not intended to enable estimation of the prevalence of each of these categories in the population, it does highlight the need for teachers to be aware that all groups might be represented even in an apparently homogenous classroom. Other findings in the study suggest that Science teachers in particular might over-estimate the lack of variability in classroom engagement with, and acceptance of, the topic. As a consequence, their teaching fails to take account of the diversity of student positions. For religious students, the influence of family and religion tended to predominate on this issue, so it can be expected that if there is an unresolved and unacknowledged clash between the scientific view and their existing stance, it will be the former that they reject. This might result in alienation from science more generally. Awareness of the typology might persuade teachers of the importance of challenging their own preconceptions about their student body.

The use of the typology of engagement is not limited to the context of the origin of life and the universe. There is potential to expand its application to other potentially controversial or sensitive topics across the curriculum – considering it, for instance, when tackling areas as disparate as abortion, the war on terror and immigration.

It would be worth investigating, using a quantitative methodology, whether the typology can be reliably mapped onto a series of statements which teachers could then administer to their students in order to gain a greater insight into their propensity to engage with a topic. This might help steer their choice of pedagogy and, where appropriate, could be shared at a class level with the students to reassure them of the range of viewpoints and thus encourage participation.

10.2 The research questions

The over-arching driver for this research was to explore issues that might be raised when a topic is taught in two separate school subjects, and when there is potential for what is being taught to conflict with students' cultural or religious background. The intention was to use the teaching of the origin of life in Science and RE as an illustrative example. The focus was subsequently broadened to include the origin of the universe when it became apparent that the two topics were commonly conflated by research participants (Section 6.5.2).

The research questions were as follows:

1. What are Science and RE teachers' opinions about teaching scientific and religious explanations of the origin of life?

2. What are students' opinions about the scientific and religious explanations of the origin of life?

3. What are the differences, if any, between how the origin of life is dealt with in Science and RE classrooms?

4. Are there differences between students' own religious or cultural beliefs about the origin of life and what they are taught in school? If so, how do they accommodate these?

10.3 Key findings

10.3.1 Science and RE teachers' opinions about teaching scientific and religious explanations of the origin of life

Teachers' ratings of the topic of the origin of life covered the spectrum from "very" to "not at all" controversial, with a higher proportion towards the "not at all" end of the scale. Although Science teachers were more inclined than RE teachers to consider it controversial, this difference did not reach statistical significance. Reporting on classroom experience, more Science than RE teachers had found it controversial. Such controversy had most commonly been triggered by inflexible student positions - most usually in the form of religious literalism, although in other instances some students had refused to respect religious views. The problematic student standpoints were underpinned by a conceptualisation of religion and science as oppositional entities. However, controversy was not always perceived as detrimental. Several teachers reacted positively to encountering a range of contradictory opinions within their lesson, seeing it as an effective way to stimulate debate.

There was further lack of consensus among teachers about the importance of covering religious beliefs about the topic in the Science classroom. The spread of opinion was comparable among teachers from both RE and Science backgrounds. Although the nature of the justifications for including reference to religion was common across both sets of teachers, the relative frequency of each differed. For RE teachers, the most common justification was to explore the different perspectives on the issue, often described as providing students with “balance”. This reason was followed some way behind by introducing such beliefs to demonstrate that science and religion can co-exist. The main motivation for Science teachers was the promotion of tolerance and understanding. For those teachers who considered it not at all important to make reference to religious beliefs, the main factor (regardless of subject taught) was their perception of religious and scientific truths as based on totally different truth systems and epistemologies.

10.3.2 Students’ opinions about the scientific and religious explanations of the origin of life

As with some RE teachers, the responses students gave to questions about how life on earth began suggested there was a widespread lack of clarity about the distinction between the origin of life and the origin of the universe; in RE lessons the two were often considered together. Also, big bang theory had more top of mind awareness as many students claimed to have studied it more recently than evolution. Consequently, they often mentioned the big bang rather than (or as well as) evolutionary theory when referring to scientific explanations.

Students’ religious background had a considerable influence on how they explained the origin of life or the universe. The overwhelming majority of Muslims in the sample believed that God was the single causal factor in creation, whereas Christians tended towards an explanation that combined science with a divine element. As would be expected, those with no belief preferred scientific explanations. A similar pattern was evident when students were asked which of three accounts they preferred to explain the origin of human beings. Thus, most Muslims believed humans were created by God in their current form;

over half the Christians thought they had developed with some intervention from God; and most of those with no faith said they had developed with no intervention from God.

Because the case schools were selected to represent different religious intakes, it is unsurprising that students' chosen accounts of origins varied by school in a manner which reflected their religious profiles. Students in School A (primarily Christian) tended either to opt for a religious/scientific mix or a science-only explanation; in School B (mainly Muslim), most students based their response exclusively on divine creation; and in School D (split primarily between those with no belief and Christians) the most popular answer was science only. Two things are of note. Firstly, not one survey answer in School B featured a mix of religion and science, yet some students in the focus groups did claim to accept such a scenario. Although it could be a quirk of sampling, it could also be a discrepancy resulting from whether an intermediary was present (the anonymity of a questionnaire maybe enabling more honesty than the researcher in person). Secondly, whilst School D students were the most likely to adhere to a science-only explanation in the survey, the proportion opting for a religious-only explanation of the origin of life or human life was approximately the same size as that at School A despite the latter's higher percentage of Christians.

Two issues are raised by this. The first concerns students who are in a minority in terms of their beliefs about the origin of life or the universe, as with those School D students who believe that "God created life on earth, including human beings pretty much in their current form". Crucially, it was apparent from teacher interviews that there was no expectation of these beliefs being held by anyone in the school. In the focus groups, students talked about their classmates self-censoring out of concern for their peers' reaction or respect for teachers' knowledge. This leads to the danger of hidden minorities whose needs may not be appreciated and who therefore struggle to accommodate and fail to succeed in Science lessons. In School B, on the other hand, teachers were aware of the locus of religion in student learning, but still worried that students remained silent when they disagreed about such topics. The students seemed to be reluctant to challenge the orthodoxy of school or science despite not necessarily being in accord with it.

10.3.3 Differences between how the origin of life is dealt with in Science and RE classrooms

Teachers' main focus was, as would be expected, on dealing with the origin of life from the perspective of their own discipline. However, most Science teachers reported mentioning religious explanations in their coverage of the origin of life, and most RE teachers mentioned scientific theory. Because there is a large degree of latitude in the interpretation of the term "mention" in the questionnaire, it is not possible to state the precise level of discussion across the sample of schools. Most RE teachers proclaimed their confidence in teaching scientific theories, although the study found that it is amongst those teachers that confusion between the origin of life and the big bang can be found. But less than half the Science teachers were equally confident about covering religious explanations in their lessons.

Inter-departmental relationships could be useful, both to ensure that the RE teachers' confidence is well-founded, and to support Science teachers in tackling the religious aspect. Yet there was resistance to such collaboration, with lack of time commonly cited as the major obstacle. Very few teachers reported close collaboration between departments. This implies that confusions (such as between big bang and the origin of life) and lack of lesson co-ordination (topics being introduced inconsistently in terms of content and timing across the two curricula) were rarely addressed. Consequences could include the proliferation of barriers to student understanding as well as engagement.

From a student perspective, stark contrasts were drawn between the Science and RE classroom. As a school subject, Science was seen as evidence-based, privileging fact, predicated on having one correct answer, and not encouraging questioning. They perceived RE, on the other hand, as being about belief and experience, dealing with a range of views and welcoming inquiry and challenge. Consistent with this, Science was portrayed as adopting a more passive pedagogy, dominated by teacher talk, whereas RE involved more interaction with and between students.

It was felt that the two subjects considered themselves to be in competition with each other, although students thought RE departments felt the rivalry less keenly. This certainly seemed to be the case among the staff interviewed at School D as well as being reflected in some comments on the teacher questionnaires.

As a consequence of these findings, four key dimensions emerged in a model of the different natures of school Science and RE (Chapter 8). Each dimension was represented on a bipolar scale. On the foundation of knowledge scale, Science tended to be associated with fact whereas RE was seen to privilege a belief system. In terms of tolerating uncertainty, Science needed resolution whilst RE could live with more ambiguity. On open-mindedness, Science was perceived to expect an unquestioning acceptance in contrast to the discursive approach of RE, which was seen as positively encouraging expression of opinion. Less consensus was achieved on the final dimension, about how the two disciplines regarded each other. It was felt that the two were more in competition than in harmony, with the rivalry being slightly more intense from Science towards RE than vice versa.

As a result, theories of origins were felt to be treated primarily as facts beyond dispute in Science. In RE lessons, students felt more able to express their own views about the topic in an open, questioning spirit. Although student perceptions of the nature of science were only tangential to this study, the evidence suggests that, despite its increased prominence in the Science curriculum over recent years, relatively unsophisticated concepts still dominate.

10.3.4 Students' accommodation of differences between their religious or cultural beliefs about the origin of life and what they are taught in school

It is important to consider the factors behind students' positions on the origin of life to put their ability to accommodate differences into perspective. Judging from the factors they selected as the major influences on their views, school was generally of secondary importance. For those who believed in a wholly religious account of origins, their religion was the primary influence; and for those who held to a mix of religion and science, the family was key. A number of factors (family, teachers and the media) shared prominence among those who accepted a solely scientific explanation. The priority given by religious students to faith and family suggests that, if they find it impossible to reconcile messages from school with their religious or cultural background, it will be the science that they reject.

Most students thought it was acceptable to introduce religious beliefs into the Science lesson, and even important in ensuring that students' beliefs were respected. There were however caveats: the religious angle should be raised by the student not the teacher, and the teacher should make clear that the scientific version is the only one acceptable in the exam.

Many students perceive science and religion to be in an inharmonious relationship based on tension or incompatibility. This underpins how they engage with the explanations of origins as taught in school. A typology has been proposed to illustrate the main characteristics of how groups differently engage with the topic of origins:

> Resistors are unshakeably committed to their belief system and are not prepared to entertain views they consider to be conflicting. This usually takes the form of refusing to engage with scientific perspectives because they anticipate it will contradict with the religious framework in which they operate. Muslim students from School B were particularly likely to fit into this category.
>
> The Confused are split into two sub-groups. Some have tried and failed to reconcile the religious and scientific explanations, leaving them to struggle with perceived incompatibilities. For others, it was not something they had seriously

considered previously and they were unable to reach a coherent viewpoint during the comparatively short timeframe of their involvement with the research.

The Reconciled do not experience conflict between their religious and scientific understandings of the topic. For some this was a result of careful deliberation, but for others it was a position based on lack of self-exploration and challenge. The latter were likely to be less secure in the category, and further investigation might reveal them to be Resistors or Confused.

Explorers are eager to investigate the complexities of the topic and seem prepared to amend their worldview if sufficiently convincing evidence makes it appropriate. They are open-minded and both able and willing to apply their critical thinking skills to the topic. Only a few Explorers were identified in the research.

Rejectors do not recognise the question of how life on earth came into being as an important or relevant one, and consequently did not fully engage with the research. They conceptualise science and religion as being in an oppositional relationship, and privilege knowledge derived from facts rather than belief.

The model outlined above is based on qualitative work with a relatively small sample from specially selected schools. As such, it is designed to give an impression of the complexities that lie behind the thinking around this topic rather than a framework that can be applied rigidly. Further research is needed to explore these issues which have implications for the scientific education of a considerable number of students (Section 10.7).

10.4 Implications for practice

Overall the study indicates that many teachers underestimate the extent to which the topic of the origin of life is controversial and troubling to some students. As a result, there was little active intervention to offer support. It is possible to make recommendations for how the topic might be handled in the classroom by looking at the study from two perspectives: the literature about teaching controversial issues and work in the field of cultural studies in education.

The study lends support to the treatment of the origin of life as a controversial topic in certain circumstances. Survey responses from teachers and students showed that it met at least two of the criteria commonly included in the definition of a “controversial issue” (Hermann, 2008; Levinson, 2006; Oulton et al., 2004). Firstly, there are different and conflicting explanations about how the universe and life – including human life specifically – originated. Secondly, sizeable numbers of respondents hold different viewpoints about which of the available explanations is correct. It would be difficult for these people to engage in constructive debate about the evidence because they would be referencing different sources (either the scientific proof or the writings and beliefs of their religious tradition depending on their outlook). However, there are many teachers and students for whom the topic is completely uncontroversial since they consider the weight of evidence overwhelming.

If teachers decide to treat the topic as a controversial issue there are implications for their pedagogical approach. By adopting neutrality, they choose either to give equal support to different viewpoints (affirmative neutrality) or not lend support to any viewpoint (procedural neutrality) (Bridges, 1986). However, this is a controversial stance among educators as some argue that attempts at neutrality are in fact subject to hidden bias (Ashton & Watson, 1998; Oulton et al., 2004). Instead, these authors argue that if the teachers' stance is made transparent, students can judge their input accordingly. Evidence from this study suggests that RE teachers are more likely to adopt neutrality whilst Science teachers openly advocate their own opinion on the topic, perhaps closing down engagement as a result. There is a danger that the positional power of the teacher attaches to their views thus reducing even further the propensity for students with alternative positions to participate. The Confused in particular might be in this bracket.

Some Science teachers might be reluctant to adopt the strategies applicable to teaching controversial issues because of the risk of "teaching the controversy" or including non-scientific material. They might be more willing to engage with such an approach once evidence of the problems some students experience is outlined. For instance, Resistors might perceive the presentation of the topic shorn of any recognition of its controversial nature as an attempt at what Jegede and Aikenhead (1999) termed assimilation – having to relinquish their home culture in order to accept the scientific orthodoxy. Being faced with a stark choice between abandoning their religious beliefs or rejecting scientific explanations is likely to further alienate them from science. The challenge is to find a classroom strategy that enables all students to engage with the topic without risking self-censorship or estrangement. Appreciation of the different typologies outlined in this study, and how the needs of different students vary, might help teachers find appropriate ways of conveying scientific knowledge and understanding without causing alienation from the subject.

Evidence from the study suggests that the heterogeneity of student opinion surrounding the topic of the origin of life may not always be apparent to teachers. Consequently, they can be unaware of silent minorities or even majorities in the Science classroom who have objections to the theories they are being taught but do not express them. The silence is particularly problematic if it is indicative of a lack of engagement that could threaten the student's relationship with science more broadly. The problem may be exacerbated if the teacher holds false assumptions about the students' worldviews. For instance, because the catchment area of School D did not draw from a particular faith group, teachers took it for granted that no student would hold opinions that were irreconcilable with the scientific orthodoxy. Yet one in ten of the students from School D who responded to the survey believed that humans had been created by God in their present form.

As might be predicted from their shared cultural and religious backgrounds (primarily Bangladeshi Muslims), students at School B tended to opt for religious explanations. However, variety was apparent in their propensity to engage with the topic. Analysis of the student sample at School B detected all five engagement types (albeit only one representative of Rejectors, the group that regards the topic as irrelevant or unanswerable – and she had no religious belief). This shows that common cultural background cannot be used as a predictor of engagement.

Another way of considering pedagogy is through the lens of cultural studies. One approach is to enable students who find that science clashes with their religious beliefs to maintain their own worldview and add other, scientific concepts for use in the appropriate context. This can be achieved through a form of collateral learning (Jegede & Aikenhead, 1999), which results in two sharply defined and compartmentalised areas of knowledge. For Resistors, this might take the form of cognitive apartheid (Cobern, 1996), an extreme form of collateral learning where the science knowledge is carefully pigeonholed so that it does not come into contact with the conflicting worldview. Explorers, on the other hand, should find it possible to achieve secured collateral learning, where mismatches between the two schemata are resolved through interaction.

Teachers might find it beneficial to adopt the role of "culture broker" (Jegede & Aikenhead, 1999) to help students constructively engage with and manage any differences they encounter between science and religion. Teachers can vary the level of guidance they provide to suit the students. To use Jegede and Aikenhead's tourism metaphor, they can act either in the more intensive role of "tour guide" or the less directional one of "travel agent". The Confused, for instance, need help to reconcile different worldviews, and sensitive nurturing to allow them to move on to one of the other categories. A tour-guide teacher introduces them to key parts of the body of science and the way it operates, aiming to give them an appreciation of science rather than turning them into scientists. This approach demands a variety of pedagogical styles. Explorers are more equipped to take charge of their own conceptual development so the travel agent approach would be more appropriate. This is not radically different from the tour guide except in the amount of direction provided. Students are seen as much more capable of guiding their own learning, if sparked by appropriate resources and teaching methods to cross from their everyday world into the culture of science, and see its inter-connectedness with other sub-cultures.

For teachers to adopt the role of culture broker successfully, they need to know the workings and language of each “culture”. From the study, it was apparent that teachers did not always have an accurate picture of the situation among their students, and this seemed more prevalent in the Science departments. Reliance on the approach described by Mortimer and Scott (2003) as interactive and dialogic, where the teacher listens to students and takes account of their opinions, might be the most enabling. Unfortunately, reports from students and some teachers suggest that a transmissive pedagogy is not uncommon in the Science classroom and this risks stifling debate and reducing involvement.

The challenge for teachers is to identify a way of successfully connecting with all their students regardless of conceptual perspective or engagement type. Teachers need to recognise that the goal is not to convince students of which worldview is “correct” but to examine the available evidence without condemning a student’s existing worldview. RE teachers are legally bound to avoid proselytising in the classroom, yet comments made in this study suggest that there are a number of Science teachers whose evangelising approach to their subject risks alienating some students. Initially this may cause failure to engage with and consequently understand the theory of evolution, but such a fundamental deficiency might then adversely affect a student’s ability to access other areas of science.

10.5 Implications for the curriculum

The main curricular implication arising from this study was the importance of developing links between the Science and RE departments. This could have a variety of ramifications including: increasing teachers’ knowledge and confidence when having to cover matters that sit more comfortably in the other subject area; encouraging better co-ordination of the curricula; improving teachers’ understanding of the issues; and changing students’ potentially negative perception of the two disciplines being in opposition.

The study reveals an existing picture of no or minimal co-operation between the Science and RE departments and a lack of coordination in topic coverage between the two. Some students pointed out that this had started early, when they learnt about religious explanations at primary school but had to wait until secondary education for the equivalent science. Additionally, depending on the syllabus followed, the scientific theories could be introduced in RE lessons at least a year prior to them being covered in Science.

In the teacher survey, there was a range of opinion about whether religious beliefs should feature when the topic is being taught in the Science classroom, but the reality was that most of the Science teachers and nearly all the RE teachers were to some extent including both scientific and religious explanations already. However, this was happening in the context of little or no collaboration between the two departments in most of the schools surveyed. The risk is that scientific theories are represented inaccurately in the RE classroom, and that potentially sensitive religious and cultural issues are raised with or by Science teachers inexperienced in, and unsure about, dealing with them.

The majority of RE teachers expressed confidence in teaching scientific explanations, but in the absence of any input from the Science department, it is unclear how justified this is. The RE staff in School B had encountered unexpected problems when attempting to teach the big bang theory to students in Year 9. In view of the documented extent of students' misconceptions about evolutionary theory, and debates about how best to tackle these in the classroom (eg Jones & Reiss, 2007; Nelson, 2008), it is important that teachers in the RE classroom – where students may first encounter the theory – are adequately supported.

Science teachers were less confident in handling religious explanations than their RE colleagues were with the science. Science teachers can be uncomfortable dealing with ways of knowing outside the scientific, yet such approaches may be necessary to engage students with different worldviews. By adopting an overly defensive position, a Science teacher may fall into the trap of alienating students who react against the perceived rigidity of scientism. RE teachers are in a position to provide Science teachers with the skills and confidence to handle sensitively conflicts between the scientific and religious explanations for the origin of life, or to act as support if the Science teacher feels they cannot manage a situation by themselves.

There was an unanticipated confusion between the origin of life and the origin of the universe among students and, to some extent, RE teachers. This emerged at the pilot stage and, after discussion with my supervisor, the decision was taken that student understanding was such that it would be impossible to disentangle the two prior to analysis. But that finding, confirmed in the main study, is important in itself and underlines the need to ensure that terminology is used consistently in teaching and research. One recommendation is to co-ordinate students' introduction to the theories of the big bang and the origin of life between the Science and RE departments. As well as ameliorating the issues of knowledge and confidence outlined in the previous paragraphs, this might help ensure the distinctions between the two forms of origin are understood.

The adoption of a silo mentality in schools can make it difficult for students to explore the relationship of scientific and religious positions as they are customarily kept separate. Closer departmental links might encourage those students who perceive a disconnect between science and religion to re-examine their view.

As a cross-curricular theme, the interaction of religious and scientific thinking in topics such as the origins of life and the universe has potential to act as an exemplar of controversial issues. In turn, the teaching of controversial issues can develop critical thinking and argumentation skills, and in this specific case can challenge potentially unhelpful assumptions about the relationship between science and religion.

In England, current government guidance (DCSF, 2007) implies that issues of creationism and intelligent design should only be tackled in Science classes if raised by students. This study suggests that, although students may be struggling internally with the conflict, they might never voice their doubts. Schools might want to consider whether they have individual circumstances – for instance, a high proportion of Resistors – that justify the topic being specifically tackled in a cross-curricular collaboration whose outcomes are carefully monitored. In other schools, teachers need to be aware that – even though the scientific theories might not be challenged in the classroom – there is likely to be at least a small minority of students for whom they cause conflict.

Although lack of time was often given as a reason for the absence of inter-departmental collaboration, the evidence suggests it would be time well spent if it helped boost teachers' confidence, and could also act as a check that RE teachers were covering the science adequately and accurately. Science teachers could use the theme to explore how science works, emphasising characteristics of the nature of science such as open-mindedness, its tentative nature and the role of creativity in the classroom. Otherwise there is a clear danger that some students are antagonised by, or even estranged from, science and perceive its teachers as blinkered, inflexible and defensive.

The secondary school landscape is changing, with the Academies Act 2010 enabling academies and free schools to be set up outside Local Authority control and with greater autonomy over admissions and the curriculum. Although released from the strictures of the National Curriculum, they are still bound by the 1988 Education Reform Act to provide religious education for all children unless they have been withdrawn by their parents. The government website[7] explains that the type of RE offered will depend on the funding

[7] http://www.education.gov.uk/schools/leadership/typesofschools [Retrieved March 29, 2012]

agreement and religious designation of the school, but the requirements are in line with those applying to local authorities and maintained schools.

On the same website, one of the four “frequently asked questions” listed in relation to the free school curriculum asks whether they can teach creationism or intelligent design, and exclude evolution. The response states that evolution would be expected to feature in the science curriculum and no state-funded school should cover creationism or intelligent design as valid scientific theories. It is not so much the reply which is interesting, as this matches existing advice, but that the Department of Education has chosen to give the query such prominence. This indicates that they are prepared for it to be an issue and indeed have been for a while. Michael Gove (Secretary of State for Education at the time of writing), said in a television interview when he was still Shadow Schools Secretary (BBC, 2010):

> [...] to my mind, you cannot have a school which teaches creationism. And one thing that we will make absolutely clear is that you cannot have schools which are set up, which teach people things which are clearly at variance with what we know to be scientific fact.

10.6 Strengths and limitations of the study

This study used opinions about the origin of life to draw broader conclusions about how students and teachers engage with school Science and RE, and the inter-relationship between science and religion more generically. The extent of this extrapolation needs to be considered when reflecting on the findings. Cobern and Loving (2000) warn against projecting attitudes towards science from attitudes to evolution. Whilst it is true that rejection of evolution does not equate to rejection of science, my argument is that it could adversely affect the relationship.

Various practical considerations imposed constraints on this study. It was not possible to apply all the elements of the grounded theory approach. For instance, limits of time and scale along with logistical problems arranging school visits adversely affected the pursuit of theoretical sampling (determining future data collection based on what concepts are emerging) and theoretical saturation (carrying out interviews until new ones will provide no further insights). However, Corbin and Strauss (2008) are pragmatic about such difficulties: “A researcher should never become upset by not being able to ... obtain access to a theoretically relevant site or person(s). Rather, he or she should make the most of what is available to him or her” (p. 155).

One potential weakness of a PhD study of this nature might be that one individual is responsible for the collection and interpretation of the data, decisions about what codes to use and what themes to draw out. However, I was in the fortunate position of having two experienced supervisors to scrutinise and discuss my decisions with, and the use of grounded theory kept the analysis close to the data. It also meant there was a consistency of approach difficult to guarantee with more than one researcher involved.

It has been stressed already that this study was exploratory and illustrative rather than generalisable to a wider population of teachers and schools. Modest response rates to the postal survey mean the teacher sample cannot confidently be described as representative. The response rate for Science teachers was particularly poor but the anonymity of the questionnaires precluded further exploration of the issue. If it had been possible to contact a sample of non-respondents, questions could have been asked to establish whether the problem arose from pressures on the sample (eg lack of time) or lack of interest in the survey topic.

The case schools were deliberately chosen to represent specific scenarios and so, by definition, will not be representative of all schools. They had additional characteristics that made them distinctive. For instance, School B (selected to represent a non-faith school with a majority Muslim catchment) was also a girls-only school with students of primarily Bangladeshi heritage. These gender and ethnic features, as well as the Muslim identity of the students, may have had a bearing on the findings.

Nevertheless a sufficient degree of consistency emerged overall to suggest the findings could be usefully related to other contexts. This does not mean that they can be extrapolated to frequencies of occurrence. To quote Yin (2003):

> case studies […] are generalizable to theoretical propositions and not to populations or universes. In this sense, the case study […] does not represent a 'sample', and in doing a case study, your goal will be to generalize theories (analytical generalization) and not to enumerate frequencies (statistical generalization) (p.10).

Triangulation of the findings through the use of mixed methods proved an important credibility check. Some discontinuities between the data collected by questionnaire and from focus groups served as a reminder that responses could not be taken at face value (for instance, inconsistency about the accepted explanation of the origin of life among students at School B depending on whether they were participating in the survey or the focus groups). With hindsight, it would have been beneficial to expand the opportunities for such triangulation. Longer student questionnaires could probably have been used without jeopardising the response rate.

Inevitably there would be tweaks and changes to the question wording if the study were to be repeated. Some alterations were made to the student focus group schedules as the research progressed but, to ensure consistency, not too many changes could be made. If doing a further similar study with adolescents, I would introduce more stimulus material to enable the naturally less forthcoming students to express themselves non-verbally.

10.7 Future research

The four case school contexts represented in this research were primarily monocultural. It might be instructive to extend the research to students at schools where several cultural backgrounds, as well as a mix of faiths, are represented. Muslims from a Turkish background, for instance, might differ in attitude from those of Bangladeshi heritage. The experience of students who are in small or large religious minorities within their school is also worth investigating more closely. It is important to develop ways of accessing students who are less visible and less vocal. One way of achieving this would be through developing a questionnaire designed to quantify the engagement typology.

The typology emerging here has developed from small and non-random samples. It would be possible to develop a battery of questions related to the proposed categories and administer them to a larger sample more representative of the student population as a whole. Factor analysis and clustering techniques could be used to check whether a similar typology could be derived from this broader group.

Lesson observations formed only a small part of this study, because it was quickly realised that the presence of an observer might be having an undue influence on the lesson content. Resource limitations were also a factor. However, lessons form a potentially rich data source, if an efficient method of studying them could be devised. Possible tactics include disguising the specific interest in the teaching of evolutionary theory by observing a suite of lessons, examining documentary evidence such as lesson plans, and interviewing teachers and students about the content and process of the lesson soon after it has taken place.

An avenue worth exploring would be using researchers from backgrounds similar to the participants, for example having Muslims running discussions with Muslim students and perhaps even training a team of school students to investigate attitudes among their peers. This would furnish a different perspective from which to examine the theoretical frameworks proposed in this thesis.

Appendix

Appendix 1: Research instruments

1.1. Science teacher pilot questionnaire
1.2. RE teacher pilot questionnaire
1.3. Student pilot questionnaire
1.4. Science teacher final questionnaire (+ covering letter)
1.5. RE teacher final questionnaire (+ covering letter)
1.6. Student final questionnaire (+ covering letter)
1.7. Teacher interview guide
1.8. Science teacher discussion guide (School D)
1.9. Student discussion guide

Appendix 1.1: Science teacher pilot questionnaire

Teaching about the origins of life: Science Teacher Survey

Q1 In your science lessons, do you cover the origins of life - how life on earth as we know it today came into being?

☐ Yes ☐ No – GO TO Q4

Q2 Approximately how many hours do you spend on it at:

☐ KS3 ☐ KS4 ☐ KS5

Q3 Which of the following do you usually mention during your teaching of this topic? TICK ALL THAT APPLY

☐ religious beliefs about creation (please specify)

____

☐ Darwin's theory of evolution

☐ other scientific theories (eg Lamarck) (please specify)

____

Q4 How controversial do you personally think this topic is?

very controversial ←→ not at all controversial

☐ ☐ ☐ ☐ ☐

Q5 Have you ever found this topic controversial in your classroom?

☐ Yes ☐ No

Q6 If yes, please give some detail (reasons why, frequency etc)

Q7 How important is it to cover religious beliefs about the origin of life in the science classroom?

essential ←→ not at all important

☐ ☐ ☐ ☐ ☐

Q8 Please explain briefly the reasons behind your answer at Q7.

Q9 How confident do you feel about covering religious beliefs about the origin of life in the science classroom?

very confident ←→ not at all confident

☐ ☐ ☐ ☐ ☐

Q10 Which of these 3 explanations comes closest to describing how you think life on earth came into being? (Tick one box only)

☐ Human beings were created by God pretty much in their present form.
☐ Human beings have developed over millions of years from less advanced forms of life. God had some part in this process.
☐ Human beings have developed over millions of years from less advanced forms of life. God had no part in this process.
☐ Other (please give details) ____
____

Q11 How would you describe your religious faith? (Tick one box only)

☐No faith – (Go to Q13) ☐Buddhist
☐Christian ☐Hindu
☐Jewish ☐Muslim
☐Sikh
☐Other (please write in) ____
☐Not sure – (Go to Q13) ☐Prefer not to answer – (Go to Q13)

Q12 Would you say that nowadays you are …? (Tick one box only)

☐Very religious
☐Somewhat religious
☐Not very religious
☐Not at all religious
☐Prefer not to answer

Q13 Is your school …

☐ Non-faith ☐ Church of England ☐ Roman Catholic ☐ Muslim ☐ Jewish
☐ Other (write in) _______________

Q14 Finally, this is a pilot survey. If you have any comments that might be useful in designing the final questionnaire – for instance, questions that were unclear or difficult to answer – they would be gratefully received.

If you would be happy to be contacted again about this research, please provide your details below:

Name:
Email:
and/or Phone no:

Thank you for your help

Appendix 1.2: RE teacher pilot questionnaire

Teaching about the origins of life: RE Teacher Survey

Q1 In your RE lessons, do you cover the origins of life - how life on earth as we know it today came into being?

☐ Yes ☐ No – GO TO Q4

Q2 Approximately how many hours do you spend on it at:

☐ KS3 ☐ KS4 ☐ KS5

Q3 Which of the following do you usually mention during your teaching of this topic? TICK ALL THAT APPLY

☐ religious beliefs about creation (please specify)

____

☐ Darwin's theory of evolution

☐ other scientific theories (eg Lamarck) (please specify)

____

Q4 How controversial do you personally think this topic is?

very controversial ←→ not at all controversial

☐ ☐ ☐ ☐ ☐

Q5 Have you ever found this topic controversial in your classroom?

☐ Yes ☐ No

Q6 If yes, please give some detail (reasons why, frequency etc)

Q7 How important is it to cover religious beliefs about the origin of life in the science classroom?

essential ←→ not at all important

☐ ☐ ☐ ☐ ☐

Q8 Please explain briefly the reasons behind your answer at Q7.

Q9 How confident do you feel about covering scientific theories about the origin of life in the RE classroom?

very confident ←→ not at all confident

☐ ☐ ☐ ☐ ☐

Q10 Which of these 3 explanations comes closest to describing how you think life on earth came into being? (Tick one box only)

☐ Human beings were created by God pretty much in their present form.
☐ Human beings have developed over millions of years from less advanced forms of life. God had some part in this process.
☐ Human beings have developed over millions of years from less advanced forms of life. God had no part in this process.
☐ Other (please give details) ____
____

Q11 How would you describe your religious faith? (Tick one box only)

☐No faith – (Go to Q13)
☐Buddhist
☐Christian
☐Hindu
☐Jewish
☐Muslim
☐Sikh
☐Other (please write in) _______________________________________
☐Not sure – (Go to Q13)
☐Prefer not to answer – (Go to Q13)

Q12 Would you say that nowadays you are …? (Tick one box only)

☐Very religious
☐Somewhat religious
☐Not very religious
☐Not at all religious
☐Prefer not to answer

Q13 Is your school …

☐ Non-faith ☐ Church of England ☐ Roman Catholic ☐ Muslim ☐ Jewish
☐ Other (write in) _______________

Q14 Finally, this is a pilot survey. If you have any comments that might be useful in designing the final questionnaire – for instance, questions that were unclear or difficult to answer – they would be gratefully received.

If you would be happy to be contacted again about this research, please provide your details below:

Name:
Email:
and/or Phone no:

Thank you for your help

Appendix 1.3: Student pilot questionnaire

Student survey: life on earth

Please answer the following questions. This is not a test – there are no right or wrong answers, we are just interested in your own views and opinions. The survey is completely anonymous – you do not need to put your name anywhere on this paper.

Q1 Can you describe how you think life on earth as we know it today (with humans, animals and plants) came into being?

Q2 Are you aware of any other explanations of how life on earth as we know it today came into being? If so, please describe them.

Q3 Which of these 3 explanations comes closest to describing how you think life on earth came into being? (Tick one box only)

☐ Human beings were created by God pretty much in their present form.
☐ Human beings have developed over millions of years from less advanced forms of life. God had some part in this process.
☐ Human beings have developed over millions of years from less advanced forms of life. God had no part in this process.
☐ Don't know/not sure

Q4 Which of the following has had **the most** influence on your views about how you think life on earth came into being? (Please choose just one answer if you can.)

☐ My family
☐ My teachers
☐ My friends
☐ My religion
☐ The media (eg TV)
☐ Other (please write in) ____________________________________

Q5 In terms of the people and groups you come across, how many of them do you think agree with your beliefs on this topic? Please answer for a, b and c.

	All of them agree	Most of them agree	Some of them agree	None of them agree	Don't know
5a My family	☐	☐	☐	☐	☐
5b My teachers	☐	☐	☐	☐	☐
5c My friends	☐	☐	☐	☐	☐

Q6 How would you describe your religious faith? (Tick one box only)

☐No faith – (Go to Q8)
☐Buddhist
☐Christian
☐Hindu
☐Jewish
☐Muslim
☐Sikh
☐Other (please write in) _____________________________________
☐Not sure – (Go to Q8)
☐Prefer not to answer – (Go to Q8)

Q7 Would you say that nowadays you are …? (Tick one box only)

☐Very religious
☐Somewhat religious
☐Not very religious
☐Not at all religious
☐Prefer not to answer

Q8 Are you male or female?

☐Male
☐Female

Thank you very much for filling this in.

Appendix 1.4: Science teacher final questionnaire

1 July 2008

Dear [Name/Position]

Science and religion inter-relationship in schools

There has been a lot of media coverage recently about the interplay between science and religion, and one focus of this has been the treatment of the origin of life in education. However, there has been very little coverage of what is really happening in schools.

I am conducting research into teachers' experiences in a cross-section of science and religious education departments across England. I would be really grateful if you could spare a few minutes of your time to fill in the short questionnaire enclosed.

The survey is **totally confidential and anonymous**: no individual or school will be identifiable. The plan is to make the findings of this research available in publications accessible to teachers.

I enclose a Freepost envelope for your response. I have also enclosed an extra questionnaire and would be very pleased if you have a departmental colleague who is also willing to participate.

Thank you very much in advance for your help - I would greatly appreciate it.

Best wishes

Pam Hanley

Freepost address:
University of Southampton, P M Hanley, School of Education, Freepost SO286, Highfield, Southampton SO17 1YN

Teaching about the origins of life: Science Teacher Survey

Q1 In your science lessons, do you cover the origins of life - how life on earth as we know it today came into being?

☐ Yes ☐ No – GO TO Q4

Q2 Approximately how many hours do you spend on it at:

___ KS3 ___ KS4 ___ KS5

Q3 Which of the following do you usually mention during your teaching of this topic? TICK ALL THAT APPLY

☐ religious beliefs about creation (please specify) ______________________

☐ Darwin's theory of evolution

☐ other scientific theories (eg Lamarck) (please specify) ______________________

Q4 How controversial do you personally think this topic is?

very controversial ☐ ☐ ☐ ☐ ☐ not at all controversial

Q5 Have you ever found this topic controversial in your classroom?

☐ Yes ☐ No

Q6 If yes, please give some detail (reasons why, frequency etc)

Q7 How important is it to cover religious beliefs about the origin of life in the science classroom?

essential ☐ ☐ ☐ ☐ ☐ not at all important

Q8 Please explain briefly the reasons behind your answer at Q7.

Q9 How confident do you feel about covering religious beliefs about the origin of life in the science classroom?

very confident ☐ ☐ ☐ ☐ ☐ not at all confident

Please turn over

Q10 How much collaboration is there between the science and RE/RS departments in your school?

a lot ←→ none at all

☐ ☐ ☐ ☐ ☐

Q11 Which of the explanations below comes closest to describing how you think life on earth came into being? (Tick one box only)

☐ Human beings were created by a divine being pretty much in their present form.

☐ Human beings have developed over millions of years from simpler forms of life. A divine being had some part in this process.

☐ Human beings have developed over millions of years from simpler forms of life. No divine being had a part in this process.

☐ Other (please give details)

____

Q12 How would you describe your religious beliefs? (Tick one box only)

☐No belief – (Go to Q14) ☐Buddhist

☐Christian ☐Hindu

☐Jewish ☐Muslim

☐Sikh

☐Other (please write in) ______________________________

☐Not sure – (Go to Q14) ☐Prefer not to answer – (Go to Q14)

Q13 How would you describe the strength of your belief? (Tick one box only)

very strong ←→ not at all strong

☐ ☐ ☐ ☐ ☐

☐Prefer not to answer

Q14 Is your school …

☐ Non-faith ☐ Church of England ☐ Roman Catholic ☐ Muslim

☐ Jewish ☐ Other (write in) ____________

Q15 Are you …

☐ male ☐ female

Q16 Number of years in teaching

☐ 0-2 ☐ 3-5 ☐ 6-10 ☐ 11-20 ☐ 21+

If you would be happy to be contacted again about this research, please provide your details below:

Name:

Email: Phone no:

Please use the space below for any additional comments you may have.

Appendix 1.5: RE teacher final questionnaire

Teaching about the origins of life: RE/RS Teacher Survey

Q1 In your RE/RS lessons, do you cover the origins of life - how life on earth as we know it today came into being?

☐ Yes ☐ No – GO TO Q4

Q2 Approximately how many hours do you spend on it at:

___ KS3 ___ KS4 ___ KS5

Q3 Which of the following do you usually mention during your teaching of this topic? TICK ALL THAT APPLY

☐ religious beliefs about creation (please specify)

____

☐ Darwin's theory of evolution

☐ other scientific theories (eg Lamarck) (please specify)

____

Q4 How controversial do you personally think this topic is?

very controversial ◄────► not at all controversial

☐ ☐ ☐ ☐ ☐

Q5 Have you ever found this topic controversial in your classroom?

☐ Yes ☐ No

Q6 If yes, please give some detail (reasons why, frequency etc)

Q7 How important is it to cover religious beliefs about the origin of life in the science classroom?

essential ◄────► not at all important

☐ ☐ ☐ ☐ ☐

Q8 Please explain briefly the reasons behind your answer at Q7.

Q9 How confident do you feel about covering scientific theories about the origin of life in the RE/RS classroom?

very confident ◄────► not at all confident

☐ ☐ ☐ ☐ ☐

Please turn over

Q10 How much collaboration is there between the RE/RS and science departments in your school?

a lot ←——→ none at all

☐ ☐ ☐ ☐ ☐

Q11 Which of the explanations below comes closest to describing how you think life on earth came into being? (Tick one box only)

☐ Human beings were created by a divine being pretty much in their present form.
☐ Human beings have developed over millions of years from simpler forms of life. A divine being had some part in this process.
☐ Human beings have developed over millions of years from simpler forms of life. No divine being had a part in this process.
☐ Other (please give details)

____

Q12 How would you describe your religious beliefs? (Tick one box only)

☐No belief – (Go to Q14) ☐Buddhist
☐Christian ☐Hindu
☐Jewish ☐Muslim
☐Sikh
☐Other (please write in) ______________________________
☐Not sure – (Go to Q14) ☐Prefer not to answer – (Go to Q14)

Q13 How would you describe the strength of your belief? (Tick one box only)

very strong ←——→ not at all strong

☐ ☐ ☐ ☐ ☐

☐Prefer not to answer

Q14 Is your school …

☐ Non-faith ☐ Church of England ☐ Roman Catholic ☐ Muslim
☐ Jewish ☐ Other (write in) _______________

Q15 Are you …

☐ male ☐ female

Q16 Number of years in teaching

☐ 0-2 ☐ 3-5 ☐ 6-10 ☐ 11-20 ☐ 21+

If you would be happy to be contacted again about this research, please provide your details below:
Name:
Email: Phone no:
Please use the space below for any additional comments you may have.

Appendix 1.6: Student final questionnaire

Dear Parent

I am carrying out some research about teaching and learning in science and religious studies classes. Findings from the research may be used to help teachers in the future. [Name of school] is one of a number of schools that has agreed to help with the study. I would be very grateful if you would give permission for your daughter to take part in this research. She will also be asked to give her own permission.

<u>What will it involve?</u>
Your daughter may be asked to fill in a short questionnaire during school time. This will not have her name on it so it is completely anonymous. Some girls will also be asked if they will take part in a short discussion, along with the researcher and some classmates.

All participation is confidential and your daughter's name and the school name will not be used when reporting the findings. She has the right to withdraw from the research at any time.

If you have any more questions, you can contact me through [Teacher name].

Thank you very much for your help.

Yours faithfully

Pam Hanley
School of Education
University of Southampton

I give permission for my daughter __________________________ to take part in this research study. I understand all findings will be anonymous and confidential.

Signed ____

Student survey: life on earth

Please answer the following questions. This is not a test – there are no right or wrong answers, we are just interested in your own views and opinions. We do not need your name.

Q1 How do you think life on earth came into being?

Q2 Do you know of any other explanations about how life on earth came into being? If so, please describe them.

Q3 Which of the explanations below comes closest to describing how you think humans came into being? (Tick one box only)

☐ Human beings were created by God pretty much in their present form.

☐ Human beings have developed over millions of years from simpler forms of life. God had some part in this process.

☐ Human beings have developed over millions of years from simpler forms of life. God had no part in this process.

☐ Other (please give details)

____

Please turn over

Q4 Which of the following has had **the most** influence on your views about how you think life on earth came into being? (Please choose just one answer if you can.)

☐ My family ☐ My teachers
☐ My friends ☐ My religion
☐ The media (eg TV)
☐ Other (please write in) ____________________

Q5 How many of your **family** do you think agree with your views on this topic?

All of them	Most of them	Some of them	None of them	Don't know
☐	☐	☐	☐	☐

Q6 How many of your **friends** do you think agree with your views on this topic?

All of them	Most of them	Some of them	None of them	Don't know
☐	☐	☐	☐	☐

Q7 Do you think your **science teacher** agrees with your views on this topic?

☐ Yes ☐ No ☐ Don't know

Q8 Do you think your **RE/RS teacher** agrees with your views on this topic?

☐ Yes ☐ No ☐ Don't know

Q9 How would you describe your religious beliefs? (Tick one box only)

☐No belief – (Go to Q11) ☐Buddhist
☐Christian ☐Hindu
☐Jewish ☐Muslim
☐Sikh
☐Other (please write in) ____________________
☐Not sure – (Go to Q11) ☐Prefer not to answer – (Go to Q11)

Q10 How would you describe the strength of your belief? (Tick one box)

very strong ←——————→ not at all strong

☐ ☐ ☐ ☐ ☐

☐Prefer not to answer

Q11 Are you male or female:

☐Male ☐Female

Thank you very much for filling this in.

Appendix 1.7: Teacher interview guide

Introduction

(run through purpose of project, ground rules for interview)

General

How would you describe the inter-relationship between science and religion?

Where is the inter-relationship most evident? Anywhere else?

Do you address it explicitly in your teaching? If so, where?

Does it ever get raised spontaneously by the students? Examples?

Origin of life

What do you teach about the origins of life? (prompt if necessary about present day life on earth)

What do you yourself think about how life originated?

How do you think your own beliefs affect how you teach this topic?

Has it ever proved controversial in the classroom during your teaching career? If so, examples

Has it ever proved controversial in the staffroom? If so, examples

Do you feel the need for any further support in this area? If so, what kind of thing (eg professional development)?

Collaboration and support

Can you describe what collaboration there is in this school between science and RE departments?

What contact do you personally have with the science/RE dept?

How does this compare with previous experiences at other schools?

Personal views

(How would you summarise) your own personal views about

c) whether the science/religion overlap should be tackled in school
d) how it should be tackled eg where in curriculum, what ages, what kind of teaching approach, resources etc
e) (Stress don't have to respond) Do you have any religion/faith/spiritual beliefs?

Demographics

Teaching subject specialism (eg within science)
Degree discipline
Length of time taught

Appendix 1.8: Teacher topic guide (for Science teachers, School D)

Introduction
(run through purpose of project, ground rules for interview)

General
Do you think there is an overlap between science and religion?

Where is it most evident? Anywhere else?

Do you address it explicitly in your teaching? If so, where?

Does it ever get raised spontaneously by the students? Examples?

Origin of life
What do you teach about the origin of life? (prompt if necessary about present day life on earth)

What do you yourself think about how life originated?

Do you think your own beliefs affect how you teach this topic?

Has it ever proved controversial in the classroom during your teaching career? If so, examples and how dealt with

Has it ever proved controversial in the staffroom? If so, examples

Do you feel the need for any further support in this area? If so, what kind of thing (eg professional development)?

Collaboration and support
Can you describe what collaboration there is in this school between science and RE departments?

What contact do you personally have with the science/RE dept?

How does this compare with previous experiences at other schools?

Personal views
(How would you summarise) your own personal views about

a) whether the science/religion overlap should be tackled in school
b) how it should be tackled eg where in curriculum, what ages, what kind of teaching approach, resources etc
c) (Stress don't have to respond) Do you have any religion/faith/spiritual beliefs?

Demographics
Teaching subject specialism (eg within science)
Degree discipline
Length of time taught

Appendix 1.9: Student discussion guide

Introduction
Reason for research
How research will be used
Issues of anonymity, confidentiality
Right to withdraw at any time or not answer specific questions – indicate if feel uncomfortable
No right/wrong answers
What's discussed in the group should remain in the group
Ground rules for group, eg respect each other, try to talk one at a time

Origin of life
In school, what have you learnt about how life on earth as we know it today came into being? (prompt if necessary to cover scientific, religious and any other explanations)

How has it been taught to you eg textbooks, discussions, teacher standing in front of class talking (separate out different subjects eg Science, RE)

Probe any conflict between how it has been covered in different subjects or lessons and how this has been handled. Prompt if necessary: do the explanations seem to fit together well or do they contradict each other?

Added after initial fieldwork: If you were a science teacher and someone in your class said they didn't believe the scientific explanation because of their religious beliefs, what would you say to them?

Added in final focus groups: Have any of you changed your minds about how life on earth came into being? If so, why?

Is it a topic you have ever come across outside school?
If so, probe for: where and in what way?

Do you think it is a controversial subject?
If so, probe for: why? in what way?

Science/religion inter-relationship
Thinking of school specifically – is there any interaction between science and religion? Details? Probe for: Separate? Related? Opposed?

Do you think there is a science/religion overlap in world at large? Probe for: Separate? Related? Opposed?

Ask students to draw relationship/non-relationship of science and religion. Show sheet of example spheres.

Thank and end

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