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A life history study of the factors that influence the acceptance or rejection of the Big Bang theory and theory of biological evolution among lifelong learners

PhD

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Abstract

This study explores the factors that influence the acceptance or rejection of the Big Bang theory and the theory of biological evolution among lifelong learners. Rejection of either theory is problematic as it may restrict learners' subject choices and may in turn result in exclusion from some learning pathways, with potentially reduced options of employment. Rejection of either theory can occur despite the time that has elapsed since the original theories were proposed and their wider acceptance. The study takes a life history approach and critically examines the biographies of ten participants, establishing the factors that influence their rejection or acceptance of either theory. To select participants the researcher used purposive sampling to establish a correspondence between research questions and sampling, so that individuals who were relevant to the research questions were interviewed. Purposive sampling enabled the researcher to select participants with the goal of identifying information-rich cases, while still achieving a variety and contrast of dimensions, including age, gender, educational background and occupation. The study concludes that individuals are affected by multiple factors that result in them accepting or rejecting either or both theories. The study explores how these findings may contradict other studies which identify religious belief as the driver for rejection. The study proposes an original theory of opinion formation that is specific to both scientific theories and suggests the use of inclusive teaching methods and historical narrative within science lessons, which may assist in explaining to students the story of discovery of each scientific theory, as well as teaching the theory itself. The study also concludes that the rejection of both theories, particularly by older participants, may be linked to past discredited theories, including the Steady State theory and the theory of Panspermia.

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I would like to thank my principal supervisor Associate Professor Geoff Taggart and second supervisor Professor Naomi Flynn.

I dedicate this thesis to my parents, Monica and Frank Blagrove, and to my children, Marcus, Miles, Harvey, Elsie, Faith, Fergus and Florence.

Declaration of original authorship

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

Signed : *Ian S. G. Blagrove* (Ian S. G. Blagrove)

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Chapter 1: Introduction

1.1 The research problem

This study explores the acceptance and rejection of the Big Bang theory and the theory of biological evolution. Rejection of either theory may restrict learners' subject choices and may result in exclusion from some learning pathways, with reduced options of employment (Nelson 2000, Dawkins 2006, Sang 2011, Imgram 2011). Depending upon the curriculum used, learning in subjects such as archaeology, biology and physics can be adversely affected by the rejection of the theories of the Big Bang and biological evolution in favour of, for example, a belief in a created earth and created life having been in existence for only 6,000 years (Miles 2023, Imgram 2011, Sang 2011). Interdisciplinary subjects and humanities, as well as science subjects, can be affected. For example, the study of linguistics requires acceptance of the fact that languages originated before 50,000 BP (McGregor, 2015). In chemistry, understanding the origin of heavy elements like gold and carbon requires an acceptance of star formation following the Big Bang (May, Moore and Lintott, 2012), and the subsequent life cycles of stars (Taber, 2012), resulting in supernova nucleosynthesis (Hoyle, 1954). Foundational to the study of art history and anthropology is that carbon dating and uranium-series analysis confirm human and Neanderthal art dates from approximately 51,200 years and 125,000 years BP respectively (Oktaviana et al, 2024 and Fleming and Honour, 2009). Within teacher training, acceptance of the Big Bang and biological evolution are essential to teach some secondary and tertiary level subjects, including physics (Sang, 2011), and biology (Ingram, 2011). Rejection of either theory can occur despite the time that has elapsed since the original theories were proposed and their wider acceptance by the scientific community, and in the general population (Pew, 2015).

1.2 The thesis title, research questions and aims

The thesis title is:

"A life history study of the factors that influence the acceptance or rejection of the Big Bang theory and the theory of biological evolution among lifelong learners."

The thesis title has been formulated from the specific problem noted within lifelong learning, combined with the methodology that is used to undertake the study.

The research questions to be answered are:

1. What are the factors over an individual's life course that can result in the individual accepting or rejecting the two scientific theories of the Big Bang and biological evolution?

2. Upon identifying the factors, can recommendations be made to alter the practices within science education and practices of the dissemination of scientific theories to counter influences that unduly impact acceptance?

The research aims accompanying the questions are:

1. To examine the life histories of the participants and their opinions concerning the two scientific theories.

2. To identify how the participants' opinions developed.

1.3 Relevance of the problem and why it needs to be addressed

It is appropriate to study the topic at this time because of the pervasive cultural perception of a conflict between science and religions that can effect students' learning pathways and employment options (Dawkins, 2006). Some scientific theories appear to undermine any received views of humanity as a unique species at the apex of a created universe (Nelson, 2000 and Skehan, 2000). As science has advanced, we have discovered that the earth is not the centre of the universe and instead goes round the sun, and that humans are descended from early primates (Mosley and Lynch, 2010). The Victorian "Conflict thesis" of Draper (1875) proposed an unequivocal "struggle and conflict" between science and religion (p.5).

This proposal has been supported by Dawkins (2006) who suggests that there is a profound contradiction between science and religious belief, since religious faith, in his view, discourages independent thought. Mosley and Lynch (2010) propose a less confrontational view of the historical backdrop, suggesting instead that, by its commitment to data and facts, science in history has had the unintended ability to undermine religious belief systems, thereby appearing to create conflict.

This continuing friction may account for the rejection of the theories by some individuals in religious communities and countries. For example, in the United States variations in rejection of both theories among the population is confirmed by the National Science Teachers Association who note there is a complexity and "gradient" to acceptance or rejection of both theories and that restricting respondents to a yes/no answer on acceptance is deeply flawed (Nelson, 2000, p. 34). It proposes that, at one end of this gradient, God drives physical and biological evolution so that that these processes resulted in the creation of galaxies, our solar system, and life on Earth. This end of the spectrum, sometimes termed *theistic evolution*, is not necessarily in disagreement with scientific explanations, for example if the Big Bang is started, but not subsequently interfered with, by a God. In contrast, at the other end of the spectrum, there exists *creation science*, "a proactive kind of Christian religion that purports to be scientific", (Skehan, 2000, p. 1), which asserts earth and life were created in the same period, some 6,000 years ago. This viewpoint is based on a traditional belief formed from interpolations of the Bible's genealogical lists from Adam to Jesus, given in the New Testament and additional genealogical lists given in the Old Testament (George, 2017).

This study will identify the factors which may lead to the rejection of the two scientific theories through a process of systematic inquiry (Mertens, 2015). It will examine whether scientific evidence tends to be dismissed because of flawed teaching practices or whether there are other factors at work, such as religious influences, or problems in scientists' dissemination methods. The terms "acceptance or rejection of" are used in the title of this thesis, as opposed to "belief in" the scientific theories. This is because science is not a belief system, and instead of faith, evidence and scientific methodology are used (Williams, 2014 and 2016). Acceptance of facts, thereby forming an opinion, is different from belief that is a disposition to feel, perhaps due to faith (Cohen, 1989 and 1995). It can further be suggested

that acceptance via opinion is language dependent, while belief can be non-linguistic (Tuomela, 2000). This study will examine opinion formation that may explain the participants' acceptance or rejection of the two scientific theories. The study involves lifelong learners aged from 18 up to and including those in retirement, who can confirm their life histories to date, including their pre-18 childhood and education memories. Primary and secondary school children are not included in the study as they could not confirm any influence or effect that would occur in adult life.

1.4 The researcher's background and interest in the problem

It is important to confirm relevant details of the researcher and acknowledge any subjective and value-laden assumptions that may unintentionally influence the ontological and epistemological positions of the study (Goodson and Sykes, 2010 and Seidman 2006). These disclosed relevant details aim to endorse the transparent methodology. It is impossible to totally avoid the researcher's subjectivity being written into the study due to its reflexivity (Lincoln and Guba, 1985 and Lichtman 2006). Considerable interest is focused by Mertens (2015) on who the researcher is and what values, assumptions, beliefs, or biases the researcher brings to the study, recommending an autoethnography summary at the start of the thesis and confirming the researcher is the instrument for collecting data, deciding which questions to ask and in what order, what to observe and what to write down.

I have taught science and humanities at schools and colleges and, in addition, arranged and spoken at lifelong learning science education talks, seminars and discussion groups in the Reading area. I fully accept and agree with the theories of the Big Bang and biological evolution. For several years, while organising and undertaking classes for lifelong learners at colleges in various subjects including archaeology, history and science, my colleagues and I became concerned at the consequences of the rejection of the Big Bang theory and the theory of biological evolution, including what we saw as the students' reduced subject choice options and potentially reduced employment pathways. During this period some lifelong learners informally disclosed to me several reasons for rejection of either or both theories, including religious belief and alternative scientific theories that they were aware of, and had been influenced by. The phenomenon was also noted by me within my family,

as both my parents, who were born in the 1930s and were scientifically literate, often questioned the Big Bang and biological evolution. For example, my father preferred the Steady State theory of the origin of the universe, proposed and supported in the second half of the twentieth century by Hoyle (1950, 1990 and 1994).

During a staff training day at Reading College, I was giving a lecture on archaeology to staff, with the aim of subsequently discussing the teaching methods being used by all the presenters. During my presentation I held up various items for the group to estimate their age. To add interest, I held up a strangely shaped rock that might, to an untrained eye, look like an archaeological find. When the entire group realised it was a rock, I asked the group how old it was. The rock was approximately 65 million years old, and it contained a specific fossil. To my surprise, a lecturer who mostly taught mathematics and English, answered "about 6,000 years old". After the training day ended, I asked her why she thought that and she replied, that at some point in her life she was told that all rocks were 6,000 years old and "it stuck". This was despite her subsequently watching several television programmes on science in her life, including ones on the origins of planets and biological evolution. This personal view had impacted on her subject choice options and resulted in an inability to teach some subjects. I subsequently noted that insufficient or inadequate academic research had been undertaken to date concerning the reasons behind rejection or acceptance of the two scientific theories of the Big Bang and biological evolution.

1.5 Theoretical and conceptual definitions

Big Bang theory

The Big Bang theory can be defined as a model that fits available evidence from the Universe that is observed and measured, together with evidence from theoretical physics (Nussbaumer and Bieri, 2010). It is a collection of theories that suggest all matter and energy originated from a state of intense density and temperature, that expanded at a moment in the past that is finite and resulted in the commencement of space-time and fundamental forces, as well as matter and energy, that then inflated and continues to

expand today, so that the original process and directions are still in progress (May, Moore and Lintott, 2012).

The theory was the culmination of work undertaken by several scientists, many of whom worked independently of each other in the 20th century including Lemaitre and Hubble (Nussbaumer and Bieri, 2010). Many scholarly works of reference detail the substantial body of evidence for the Big Bang theory, (for example Nussbaumer and Bieri, 2010, May, Moore and Lintott, 2012, and Carroll and Ostlie, 2017). Despite the significant amount of supporting evidence, the Big Bang is still a theory but is "our best explanation for why space is expanding" (Battersby and George, 2017, p. 213). The evidence supporting the Big Bang theory is summarised in the following table:

Table 1. Summary of evidence supporting the Big Bang theory

The vast majority of galaxies in the universe are moving apart, evidenced by their red shift in their emitted light spectrum, caused by the object moving away from the observer, in accordance with the Doppler Effect. Those relatively small numbers of galaxies moving toward each other in galaxy clusters are being subjected to localised gravity. If the vast majority of galaxies are moving apart, the universe is expanding. If this expansion pattern is theoretically reversed there once will have been a moment, approximately 13.8 billion years ago, when all matter in the universe would have been packed together and this then expanded (Nussbaumer and Bieri, 2010).

The large abundance of helium in the universe is explained by the hydrogen fusion that occurred in the hot early universe following the Big Bang. Hydrogen fusion would only occur at this level in a very hot universe following the Big Bang (Carroll and Ostlie, 2017).

The cosmic microwave background radiation that originated from the early stages of the Big Bang has been detected on earth. Wherever in the universe an appropriate aerial is pointed a similar level is detected. The farthest areas of the universe have the highest amounts of galaxy forming gas clouds. As the light has taken 12/13 billion years to reach earth this confirms that galaxies formed from gas clouds, that had themselves formed after the Big Bang, and are made up of basic elements, for example hydrogen and helium (May, Moore and Lintott, 2012).

Quasars exist more in the distant parts of the universe than locally. The distant parts were formed billions of years ago, and it has taken this amount of time for the light from Quasars to reach us. The universe was therefore different in the past than it is today. The night sky is dark because of the expansion of the universe, resulting in dark space between the starlight that we see (Carroll and Ostlie, 2017).

The expanding universe is not infinite in age, but instead is expanding with increasing dark space between light emitting galaxies of stars and has done so for approximately 13.8 billion years. The current laws of physics support the Big Bang theory. If these laws are used in extrapolating the current observable universe backwards in time a singularity eventually results, which is the earliest state of the universe, where all matter and energy originate from a state of intense density and temperature (May, Moore and Lintott, 2012).

Biological evolution

The theory of biological evolution can be defined as the process by which all life on earth arose, from the earliest primitive organisms and their last universal common ancestor, that existed over 3,000 million years ago, giving rise to biodiversity, where there have been changes in heritable characteristics over successive generations (Law, 2017 and Futuyma and Kirkpatrick, 2017). The origins of the theory of biological evolution can be traced back to classical times when Anaximander, (c.610-c.546 BCE), proposed an early theory that suggested humans had developed from a type of fish (Winton, 2016). Erasmus Darwin, grandfather of Charles Darwin, proposed that all warm-blooded animals shared a single common ancestor, due to their great similarity (1809). The theory of natural selection was jointly proposed by Darwin and Wallace (1858), and subsequently Charles Darwin published his book, *On the Origin of Species by Means of Natural Selection* (1859). Other papers were subsequently found to support the theory, including the work of Mendel (1866), the founder of modern genetics, which is vital to the understanding and workings of evolution. Within the theory of biological evolution, macroevolution refers to evolution above the species level and microevolution refers to processes that occur within species. Macroevolution is based on microevolutionary processes, including mutation (Futuyma and Kirkpatrick, 2017). Many scholarly works of reference detail the substantial body of evidence for the theory of biological evolution, (for example Parker, 2015, Ayala and Cela-Conde, 2017, and Futuyma and Kirkpatrick, 2017).

Despite the substantial amount of supporting evidence, which continues to be accumulated, biological evolution is still a theory, although this theory provides the best explanation of all the observational evidence to date (Futuyma and Kirkpatrick, 2017). As with the Big Bang theory, the theory of evolution in modern science is an umbrella theory containing several sub-theories from different fields of study. Evolution is the unifying force in modern biology, linking together different fields such as genetics, microbiology and palaeontology in an elegant and convincing explanation for the staggering diversity of Earth's living species (George, 2017). The evidence supporting the theory of biological evolution is summarised in the following table:

Table 2. Summary of evidence supporting the theory of biological evolution

Fossil layers in sedimentary rock are found with the oldest layer at the bottom and youngest at the top. Sedimentary layers sometimes contain evidence of once-living organism in the form of fossils. Fossils at the bottom layers are very different from fossils found in top layers and bottom layer fossils are also very different from current life on earth. However, with younger top sedimentary layers the fossils look more like organisms alive today. In addition, the fossils become more complex going from bottom layers to top layers (Parker, 2015).

Life on earth has not remained the same since the first evidence of early life. The layers indicate some species arise and become extinct indicating not only that life on earth has become more complex but also that individual species do not always survive indefinitely. When the individual fossils are examined out of the sedimentary layers, similarities can be noted between extinct and living creatures, indicating they may be related in some way. This can indicate that the organisms alive today are descendants of those found in fossil records or they share a common ancestor. The individual fossils, or the layers in which they are found, can be dated, indicating a proven timeline (Futuyma and Kirkpatrick, 2017).

Current living organisms may show similarities to each other but are not exactly the same. This can indicate a common ancestor and adaptation, or evolution within different environments. DNA can be used to show how closely organisms are related. Some differences between living organisms help them adapt to different environments. This can also be noted in fossil evidence of past life on earth. The differences indicate that each species may adapt to its environment, after branching away from a common ancestor (Parker, 2015).

The study of embryos in embryology indicates embryos of different kinds of animals look very similar. These living organisms may not only be similar but also develop similarly, indicating they are related by a common ancestor. Although they have different evolved traits, the basic embryo remains the same (Ayala and Cela-Conde, 2017).

The mechanism of evolution by natural selection shows that members of a species are different from each other and can show variations. The variations may be inherited. Life forms may compete for resources and some organisms may have features that give them a greater chance of survival and reproducing. Those that survive and reproduce may pass on these features in turn to their genetic offspring (Futuyma and Kirkpatrick, 2017).

Theory in science

A theory in science is defined as a description and substantiated explanation of nature, which does not have the status of a scientific law (Hodson ,1998). In science, a law confirms there are no events that do not comply with that law, for example Newton's law of gravitation (Law, 2017). Both the Big Bang and biological evolution are scientific theories, although in common usage both are occasionally not accompanied by the term "theory" (Nussbaumer and Bieri, 2010, and Law 2017). Hodson (1998) provides a suitable definition for non-scientists, suggesting theories can be described as our "current best shot" at explaining the physical world (p. 18). He suggests they should not be regarded as true or as proven and rather they should be taken as tentative "scientific truth", (i.e., knowledge that has been subjected to critical scrutiny by other scientists). Inevitably, theories may change because of the complex interactions among theoretical speculation, experiment and observation. Gould (1981) and Chalmers (2013) suggest a theory is an explanation of factual data in linguistic analysis, where biological evolution is a theory that explains factual data, for example fossil evidence accumulated by scientific inquiry, that Lederman et al (2015) suggest is a characteristic of the nature of scientific knowledge.

Lifelong learners

Lifelong learners are defined as adults having left initial education and training, and lifelong learning is defined as all forms of learning undertaken by these adults (European Commission, 2006 and Gravells, 2012). Lifelong learning has several positive outcomes:

> Lifelong learning is important for competitiveness and employability, but also for social inclusion, active citizenship and personal development ……. [where] a lifelong learning paradigm values all kinds of learning – formal, non-formal and informal. (European Commission, 2006, p. 1).

In the United Kingdom, lifelong learning became formally recognised with teaching standards that came into effect in September 2007 (Gravells, 2012, p. 5). Teaching qualifications in the UK for the lifelong learning sector are different from those required for primary and secondary schools. These qualifications are taken in stages, PTLLS (Preparing to

Teach in the Lifelong Learning Sector), allowing supervised teaching, CTLLS (Certificate to Teach in the Lifelong Learning Sector) and DTLLS (Diploma to Teach in the Lifelong Learning Sector), allowing application for QTLS (Qualified Teacher Learning and Skill) status. These qualifications are currently being replaced by new qualifications, including the Award, Certificate and Diploma in Education and Training (Gould and Roffey-Barentsen, 2018).

1.6 How this study was designed and conducted

The choice of methodology was informed by the theories of belief and opinion formation given in the literature review (Turner and Oakes 1986, Tajfel 1982, Kegan 1982, Fowler 1995, Glover 2014, Kim 2022, Chacoma and Zanette 2015, Medo, Mariani and Linyuan 2021, and Chan, Duivenvoorden, Flache and Mandjes 2024), together with the literature review's conceptual framework of possible influences, and the research questions of the study. Having considered opposing paradigms and positions this study followed an interpretivist paradigm, ontology and epistemology that suggests individuals and groups are a product of their environment, and where they are shaped by experiences. Interpretivism aims to explain patterns in a qualitative way and the study probes value-laden concepts including perceptions, beliefs, opinions, relationships and attitudes.

Having considered various qualitative methodologies, studying the life history of individuals was most appropriate, as it would examine the individual's building and formulating of factors that influence their acceptance or rejection of both scientific theories throughout their lives. The use of the life history approach enabled the study to examine the rejection or acceptance of scientific theories that may not exclusively be the result of rational logic. The life history approach to data collection was a clear fit with the chosen paradigm and an interpretivist methodology. No other approach provided the methodology that was necessary to systematically study the factors in a chronological data collection process. The life history approach provides both the possibility to learn from participants' lives and has potential to consequently effect change via recommendations. To maintain the evidence-based nature of the research, the data obtained was kept in context, so that all elements of data are not deprived of their intended meaning. This occasionally results in longer quotations from participants being used, to maintain context.

To select participants the researcher used purposive sampling so that individuals who were relevant to the research questions were interviewed. Purposive sampling enabled the researcher to select samples with the goal of identifying information-rich cases while still achieving a variety and contrast of dimensions, including age (18 – retired), gender, religion, educational background and occupation. The researcher selected 10 purposive sampling individuals for the study, undertaking a total of 20 interviews, (2 interviews per individual). For this study a semi-structured format of interviews was devised using a mixture of prompting open and closed questions to reveal insight into the factors that influence the acceptance or rejection of the Big Bang theory and theory of biological evolution among lifelong learners. In using two interviews, any interview fatigue was minimised, and certain data collected from each interview, for example dates, periods and personal views, were checked for consistency between the two.

As part of the interview process an essential element of the research was to check the level of understanding of the terms to be used in the research including Big Bang and biological evolution. If the terms were not generally understood this may indicate a lower-than-expected level of scientific literacy. Areas of life history were explored during the interviews that included parents and family, preschool years, school years and adulthood. The interviews also included questions to discover if the interviewee has any feelings about the theories, to ascertain any levels of avoidance of cognitive dissonance.

The twenty interview transcripts that resulted from the life history methodology provided significant amounts of raw data for coding. Some initial codes were devised a-priori, for example religious influences and the individual's scientific literacy, which were clearly indicated as potential codes based on the literature review. Other codes emerged during coding and thematic analysis, for example changes in viewpoints during lifetime and differences in interpretation of the same evidence. The mix of deductive and inductive enabled the researcher to have some starting codes, with the ability to create new codes as discoveries emerge. Coding cycles ultimately lead to the development of a theory grounded and rooted in the original data, which helps explain the rejection or acceptance of both scientific theories. The presentation of findings emphasizes the importance of using the participants' own words and phrases so that the findings do not inadvertently present the researcher's version of words spoken, but instead use direct quotes from the interviewees.

The interview data is held securely by Research Data Service, University of Reading (Blagrove, 2023).

The research thesis is divided into seven chapters. Following the first chapter that details the research problem, questions, aims and relevance, the literature review provides a conceptual framework of possible explanations, together with a critical review of existing literature. The methodology chapter details and explains the paradigm, ontology, epistemology and life history approach of the study. The two findings chapters are split between the influences that effect the participants, and the participants' behaviours and opinion formation that is specific to the two scientific theories. The discussion chapter examines the themes arising from the data analysis, proposing a theory of opinion formation that is specific to the Big Bang and biological evolution. The conclusion details the original contribution to knowledge that the study provides, while also detailing any limitations of the study.

Chapter 2: Literature review

2.1 Introduction to the literature review and conceptual framework

This literature review was conducted by searching several data bases, including those of Reading University and other universities, the British library, UK government services and web sites of professional associations. The literature review will explore the notion of opinion formation as developmental and socially embedded, examining the relative impact of social conditions, such as teaching methods and religious influence, which may result in individuals accepting or rejecting either or both scientific theories.

To date, the academic research that has been undertaken in similar areas to this study has often concentrated on the rejection of scientific evidence because of religious belief, with the majority of the research undertaken in the United States, concentrating on the acceptance or rejection of the theory of biological evolution alone, (for example Skehan, Nelson and Skoog 2000, Pew 2009, Moore, Brooks and Cotner 2011 and Moore and Cotner 2013). The studies undertaken often relied on simple questionnaires, with few questions and no room for variations between reductive yes/no answers, for example the Pew (2009) survey that consisted of one question with two possible responses; "Is evolution the best explanation for the origins of human life on earth? Yes / No" (p. 1). No check was made on the respondents' understanding of the term, nor was there an option to give any other answer. This reductive method may have forced respondents to pick an answer that might not conform to their own, more complex, individual views.

The existing literature suggests there may be thematic explanations for the rejection of the Big Bang theory and the theory of biological evolution, which form a conceptual framework:

- Variations in teaching methods within schools and colleges
- Effects of religious belief on science learning
- Failings in science communication methodologies by scientists and their public academic disputes
- The effect of other competing theories
- Rejection of either theory due to a fear of their implications or cognitive dissonance

Each of these possible explanations within the conceptual framework will be examined, confirming the extent to which each has or has not been the subject of studies to date. The conceptual framework suggests that the individual's views and opinions are initially formed over time as part of the process of forming a social identity from early childhood (Turner and Oakes 1986, and Tajfel 1982). Theories of belief formation, involving influences from birth, are an initial building block of understanding the opinions of individuals, (Turner and Oakes 1986, Tajfel 1982, Kegan 1982, Fowler 1995, Glover 2014 and Kim 2022).

The rich process of belief formation from childhood is often not a "one off" decision (Kegan, 1982). Instead, it is a process that can continue until death, taking shape from all aspects of life from birth to old age, resulting in a developmental process of stages in belief (Fowler, 1995). Therefore, the process of meaning-making to form perspectives and belief formation is a lifelong activity. Existing theories of belief formation include Kegan (1982) that suggest meaning making is a single process caused simply by being a person, where meaning making is effectively a life history of influences. Tajfel (1982) proposes an individual's concepts and beliefs are often based on the person's membership of social groups, including religions and political parties. Turner and Oakes (1986) suggest group membership provides feelings of personal distinctiveness and value, occasionally resulting in biased beliefs that are coherent with the group. Fowler (1995) proposes being human results in a process of meaning making that includes spiritual formation and religious faith. Individuals use a mixture of rational logic and life experiences, including influences from educational practice, religion and politics. Belief is therefore a subjective mental position that can help lead to an opinion of weather something can be accepted or rejected, being true or false in the mind of the individual (Kim 2022).

Changing opinions via revision can be difficult due to the stress that an alteration can cause, especially as an individual may have a conscious or unconscious bias to maintaining a deeply held view, for example a fundamentalist religious belief, a racist viewpoint, or an irrational belief linked to a mental or psychological illness (Glover 2014). Beliefs are subjective not objective and can be the result of a multitude of factors during a lifetime (Kim 2022). Sagan (1995) summarised the possibility that even the most intellectually capable individuals draw on many factors from their life histories to reach conclusions, some conclusions of which are factually incorrect as "intellectual capacity is no guarantee against being dead wrong" (p.

31). Many factors may be at play that explain the rejection of the two theories, even by scientifically literate individuals. An individual's opinion formation can involve a progressive evolution of a view (Chacoma and Zanette, 2015) and misleading sources can influence an opinion as it forms (Medo, Mariani and Linyuan, 2021). Further, opinion formation can play a prominent role in societies, for example the polarizing opinions regarding COVID-19 measures (Chan, Duivenvoorden, Flache and Mandjes, 2024).

2.2 Variations in teaching methods within schools and colleges

A possible reason for the rejection of the two scientific theories is the use of different teaching methods at schools and colleges. Snively and Corsiglia (2001) suggest Western Modern Science (WMS) has often been taught as a value-free system of knowledge, under a "universal" or "Standard Account of Science" (p.6). However, Osborne and Dillon (2010) state "one of the pervasive myths of our time is that there is such a thing as *the* scientific method .... the methods of the theoretical physicist developing new models are very distinct from the entomologist working in the field" (p. 27). Cobern and Loving (2004) base their definition of the Standard Account of Science on "critical areas of consensus" including views that science is naturalistic, that it is about natural phenomena, and that it is testable (p. 204). Their definition also states that "science is grounded in metaphysical commitments about the way the world 'really is'" and "science presupposes that there is order in nature .... and causation in nature" (p. 206 -207). These definitions can be contested within areas of the philosophy of science (Okasha, 2002). However, Cobern and Loving (2004) suggest "though we do not wish to minimize the philosophical complexity .... there is a pragmatic view to science that is broadly acceptable" (p. 204). Hawking and Mlodinow (2010) suggest "traditionally these questions are for philosophy" (p. 5). This uncertainty in definitions of science and the scientific method have contributed to different teaching methods in schools and colleges that can have effects on lifelong learning. This is discussed in the debate and disagreement between "universalist" science education and "multiculturalist" science education, which are antithetical teaching practices (Cobern and Loving, 2004).

2.2.1 Universalist and multicultural science education

Universalist science education suggests science is totally asocial, logical and rational, irrespective of society and culture, whereas multicultural science education suggests that science and reality are socially constructed (Cobern and Loving, 2004). Unlike universalist science education, multiculturalist science education allows other explanations of occurrences and phenomenon to be discussed within science lessons, including religious explanations of life and the universe, while still emphasising the scientific basis of theories that counter these explanations, often by using historical narrative in science lessons to explain why differences of opinion have occurred in the past and still occur today (Kenealy, 1989, Matthews, 1994, Klassen, 2007 and Evans, 2017). Elements of this teaching style are used successfully by Cox in his public broadcasts and popular science books, that use historical narrative, bringing into the discussion historical and present-day religious beliefs to explain the history and scientific basis of both the Big Bang theory and theory of biological evolution (Cox and Cohen, 2017), and by Mosley in his public broadcasts and books (Mosley and Lynch, 2010). Hawking and Lawton (2018) confirm "the powerful pull origin stories exert on our imaginations" (p. 5). The human brain pays closer attention when information is in the form of a narrative and the use of historical story increases memory retention and understanding (Bower and Clark, 1969). Green (2004) suggests memories, learning and understanding "have to do with stories not theories …. the means of presenting the information can make it exciting and unforgettable" (p.1). Mosley and Cox were not the first to use historical narrative and bring in historical and present-day religious beliefs to explain the history and scientific basis of scientific theories, as is shown by Rogers (1960), who used the same methods in his physics lectures of the mid-20th century:

> To understand physics as scientists know it, we must show its connected framework ……. the history and philosophy of science are of the essence in understanding science at a sophisticated level……. The growth of astronomy was interwoven with that of religion – and they still lie very close, since modern astronomy is bounded by the ultimate questions of the beginning of the world. (Rogers, 1960, p. viii and pp. 210-211)

One of the earliest supporters of using the history of science and the interaction of the history of religion's influence on science was Libby (1918). He suggested a century ago that science should not be taught as pure equations and unquestionable theories, but instead students should be given the historical background and any religious interaction in science subjects, as "it places the student in the current of scientific thought" (p. v). Libby goes further in supporting this method of teaching science:

> It presents science as the constant pursuit of truth rather than the formulation of truth long since revealed; it shows science as progressive rather than fixed, dynamic rather than static, a growth to which each may contribute. It does not paralyse the self-activity of youth by the record of an infallible past. (Libby, 1918, p. v)

The universalist position on the other hand defends the cohesion and resilience of the scientific method. Upon the publication of the International Council of Scientific Unions' work concerning recommendations for capacity building in science, Leon Lederman confirmed his view that scientific knowledge is universal, true and objective, and that any suggestion of multicultural science is nonsense (Jenkins, 2001, pp 17-18). Bybee (1997), supporting the universalist position, argues for increasing coherence and consistency in science education via systematic reform of different teaching practices found at state and local levels in America. More recently in the UK, Dawkins proposed that science teachers often "tiptoe too respectfully around traditional beliefs" (Dawkins, 2008, part 3), and, in his view, discussions of cultural explanations of life and the universe, other than the theory of biological evolution and Big Bang theory, should never be undertaken within science lessons (2008, parts 1-3).

Gould (1997) suggests there are two magisterial domains; science that concerns empirical inquiry and religion that concerns human values, where conflict only occurs when these two domains overlap. Cox and Cohen (2017) suggest any overlap does not always lead to conflict as there is a "no-man's-land between religion and science – a strip of intellectual land occupied, whether we like it or not, by cosmology", and that this was also "occupied" by many highly regarded and peer reviewed scientists, including Lemaitre (p. 57). A significant criticism by Matthews of constructivism and multiculturalist practice within science education is that it may allow anything to count as science (Matthews, 1993 and 1997), and

that science teachers should ensure that the latest scientific findings are made clear to all learners and that these findings may support specific scientific theories, for example the Big Bang model and biological evolution over cultural or religious explanations of the universe, earth and life (May et al, 2012).

Dawkins' view (2008) appears to be supported by several papers. For example, Verhey (2005), Moore (2007), Moore and Cotner (2009), Moore et al (2011) and Wiles and Alters (2011) that confirm the significant problems encountered by final year high school and first year university students in the United States, who studied science up to 18 while retaining various religious beliefs. Some students rejected biological evolution and the Big Bang, either having studied science curriculum up to eighteen that specifically avoided these two areas or were taught both theories along-side cultural and religious explanations of life and the universe. These academic papers confirm that some students in the final year of high school or in the first year at university subsequently required several weeks of lessons that provided the scientific evidence for the theory of biological evolution and the Big Bang theory, so that they were then equipped to continue in their chosen science degree (Verhey 2005, Moore 2007, Moore and Cotner 2009, Moore et al 2011, and Wiles and Alters 2011).

Alternatively, Wellington and Ireson (2012) propose religious and cultural beliefs should be included within science lessons as in their view “by deliberately introducing and carefully handling controversial issues in the classroom, science teachers can motivate pupils” and show that science “is not always exact, clear, certain and unproblematic” (pp. 268-9). Sagan (1995) suggests that the Big Bang is “our modern scientific myth” and “creation stories are worthy of our deep respect” (p.285). Wellington and Ireson (2012) propose that by discussing other possibilities within the science lesson, students learn to weigh up evidence, detect bias and question sources, in addition to learning skills for working collaboratively, while understanding and respecting other students and teachers who hold different beliefs and who may have different cultural and religious backgrounds. This practice may assist in the delivery of “science for all”, encouraging inclusive learning for all, among whom may be children from cultures where religious points of view are fundamentally important. Wallace (2009) suggests religion and worship of all forms are such an integral part of the human condition that they cannot be ignored. UNESCO proposes that for “science for all” to be achievable science education must take account of equality and the cultural and religious

realities of the modern world (UNESCO 1994). Cobern and Loving (2004), go further and suggest being exclusive "does not confer science with any privilege vis-a-vis other domains", and that "truth is never under the sole proprietorship of any single domain of knowledge – not even science" (p. 211). Bronowski (1973) suggests that science is not a museum of finished constructions but is instead a progression, were "there is no absolute knowledge. And those who claim it, whether they are scientists or dogmatists, open the door to tragedy. All information is imperfect" (p. 267). Reiss (2010) suggests most people think that science is just one form of knowledge and that other forms of knowledge complement science, and that in their view the origin of the universe is also a philosophical or even religious question. Billingsley (2016) and Billingsley, Brock, Taber and Riga (2016) propose that there is a cross-disciplinary nature to the teaching of the origin of life and the universe. Taber (2012) suggests "scientific knowledge is never absolute", (p. 109) and Hughes (2004) suggests teaching socio-scientific topics often involve debate, supporting the view of Wellington and Ireson (2012), that by discussing many explanatory possibilities within science lessons students, that can be from several different religions and cultures in one class, learn to weigh up arguments and evidence while respecting others who hold different views. This may increase inclusive learning within science education and may take "science for all" a stage further and perhaps reduce levels of rejection of scientific theories, such as the Big Bang and biological evolution.

Not all commentators who agree with the principles of "Science for All" or multiculturalist science education subsequently agree on the best way to advance these. For example, there are disagreements over the development of suitable curriculum, as the process involves many stakeholders including governments, policy makers, school head-teachers, governing bodies, school funding bodies that can include religious organisations, teachers, parents and pupils. Kuhn (1993) suggests that as scientific knowledge is of a vast and increasing quantity, it is best to teach the skill of participating in scientific discourse. Vinen (2000) suggests the importance of teaching focused knowledge. Fensham (2000) appears to agree with Kuhn and suggests a move to teaching "science as a way of knowing" (p. 157). Millar and Osborne (2000) suggest that scientific training is not just for the minority who subsequently pursue a science career but instead "scientific literacy" should be "offered to all", including those from different cultures and religions, by changing science curriculum (p. 191). In this respect

of making curriculum appropriate to all, Hodson (1998) identifies that students often claim science is not relevant to, or may conflict with, their lives, including their culture and religion, and therefore students may be alienated from science, particularly as the homes of both students and teachers are personal sources of learning, values, cultures and beliefs, as are the homes of governors and head teachers. According to this view it is important that teachers are aware of the potential impact, positive or negative of cultural knowledge or beliefs on the learning of science. However, the teacher should also take account of their own personal culture and viewpoints and those of the education establishment, to check these are not having an inhibiting impact on science learning. Tobin (2004) emphasises "co-participation" in that both teachers and learners need to be aware of and attempt to resolve or ease friction between science and religion or culture within lessons, otherwise "symbolic violence" can result where learners feel misplaced and devalued because of their culture and beliefs and can, as a result, decline or refuse to engage in learning science (p. 185).

Hodson (1998) suggests teaching must not "threaten, disrupt, overpower, marginalize or eventually replace long standing beliefs and values that underpin some students' sense of personal and cultural identity" (p. 136). Jegede and Aikenhead (2004) suggest there are two opposing positions of "enculturation" and "assimilation" (p. 155), the former where a student's life experiences can harmonise with science, moving to a goal of inclusive science learning for all, and the latter where the student's life experiences, culture and religion can become marginalised during teaching and learning, possibly resulting in alienation. Aikenhead (2000) warns against enculturation, placing Western science at its focus. Costa (1995) suggests some learners can have, or can develop, an ability to think differently in different situations resulting in an ability to move from family culture and belief to science classroom culture, and back.

Costa's work can be interpreted as a form of categorization that creates a sub-set category of learners that are described as "outsiders whose transitions are virtually impossible because the cultures are highly discordant" (Jegede and Aikenhead, 2004, p. 158). Some students may adopt coping strategies to avoid assimilation into Western science, for example by attempting to hold in their mind two conflicting views, perhaps one religious and one scientific. Jegede and Aikenhead (2004) suggest an emphasis should be made

concerning the assistance pupils receive in making those transitions easier, so that it is not just an emphasis on learners' coping or changing, but an emphasis on teachers providing help to learners on an individual basis and suggest that teachers proactively help learners connect their everyday lives out of school, including their culture, with science experienced in school, as this is the key to effective learning of science, where culturally sensitive science education "probes what actually occurs in the minds and hearts of learners when they are being taught science" (p154). The concept that learners can hold Western scientific thinking alongside the individual's cultural or religious knowledge is termed "collateral learning" (Jegede and Aikenhead, 2004, p. 158), although this can be criticised for again emphasising 'Western' scientific thinking. In the concept of collateral learning individuals can be in possession of and hold ideas of science alongside possibly conflicting personal cultural knowledge and religious belief. Within this concept "parallel learning" involves Western science knowledge and cultural knowledge being compartmentalised by the learner and held separately, as opposed to "secured collateral learning" where science and cultural knowledge are accommodated, and in some instances brought together (Jegede, 1995, and Hodson, 1998). "Model-dependent realism" is also used as an approach by some teachers and learners, defined by Hawking and Mlodinow (2010) as:

> Based on the idea that our brains interpret the input from our sensory organs by making a model of the world. When such a model is successful at explaining events, we tend to attribute to it, and to the elements and concepts that constitute it, the quality of reality or absolute truth. But there may be different ways in which one could model the same physical situation, with each employing different fundamental elements and concepts. If two such physical theories or models accurately predict the same event, one cannot be said to be more real than the other; rather, we are free to use whichever model is most convenient. (p. 7).

2.2.2 Traditional Ecological Knowledge and Indigenous Knowledge

Although Snively and Corsiglia (2001) suggest WMS has often been taught as a value-free system of knowledge, under a universal or Standard Account of Science, Lewis and Aikenhead (2001) suggest WMS can "inform and be informed by the nature-knowledge systems of other cultures", (p.3). Cobern and Loving (2004) suggest there may be a barrier

between multicultural and universal perspectives because of an intellectual exclusiveness on the part of the Standard Account, arguing that "science would suffer little harm, for the purposes of curriculum" with the inclusion of forms of "Traditional Ecological Knowledge", (TEK), and "Indigenous Knowledge",(IK), and that it would be a "pyrrhic victory for indigenous knowledge", (p. 209), as TEK and IK would be accepted as a token by scientific gatekeepers "extending scientific privilege from its proper domain in science and technology into other domains", (p.211). Cobern and Loving (2004) suggest a broader curriculum that involves dialogue between different ways of knowing, different methods of inquiry and different explanations and cultures, which allows the curriculum to be constantly renegotiable, taking a pluralist viewpoint of simultaneous validity, as opposed to an alternative relativist suggestion of no absolute truth at all.

Snively and Corsiglia (2001) suggest that non-Western cultures have made historically significant contributions to science and there are different ways of establishing knowledge, and that therefore the definition of science should be broadened to include TEK and IK. Stanley and Brickhouse (2001) propose that a universalist view of science is not "compatible with a multicultural approach or fully coherent as a foundation for the science curriculum", (p.35). Taking account the criticism by Matthews (1993 and 1997) of constructivism within science education that might allow anything to count as science, teachers using multicultural science education practice should ensure that the latest scientific findings are made clear to all learners, thereby giving detailed scientific theories such as the Big Bang and biological evolution, that are supported by evidence (Osborne, 2011, p.231). Siegel (2002), in taking a universalist approach, does not wish "anything" to count as science and requires theories to be testable, predictive, explanatory and transparent. He suggests universalism is not incompatible with multiculturalism as it can be morally justified, even though in his view WMS is superior to "ethnic sciences" as WMS produces deeper understanding by producing "testable, predictive and explanatory theories" (Siegel, 2002, p.809). His suggestion that "ethnic sciences" are inferior may be offensive to adherers of the multiculturalists' viewpoint.

TEK and IK have been used successfully by some science educators in the development of local curriculum (Aikenhead 1997, Kawagley et al 1998 and Spencer 1996). Aikenhead suggests both Western scientific knowledge and TEK/IK "seek knowledge, the Westerner as

revealed by the power of reason applied to natural observations, the Native as revealed by the power of nature through observation", (1997, p. 16), aiming for students to "master and critique scientific ways of knowing without, in the process, sacrificing their own personally and culturally constructed ways of knowing", (p. 18). With this principle in mind, Aikenhead (1997) worked on a curriculum for Canadian First Nation students who represent over three-quarters of students in northern Saskatchewan, which addressed several of the nine agendas to promote inclusive science education of Pomeroy (1994), especially the agendas of culturally sensitive instruction, and exploring the content and epistemology of scientific and indigenous knowledge systems. Kawagley et al (1998) undertook similar work in south-west Alaska for Yupiaq students using an IK-based system that takes into consideration the Yupiaq view of a "holistic view of science .... emphasising the interconnectedness and interdependence of all dimensions of nature and human activity" (p. 141), that resulted in lessons combining cultural and experimental techniques. A similar cultural emphasis is found in the work of Spencer (1996) who introduced local cultural and traditional activities to science lessons that concern light and colour.

2.2.3 Avoiding isolation and achieving inclusion in the science classroom

Biggs and Tang (2011) suggest "ethnic diversity in the classroom undoubtedly raises issues of teaching and learning" and that it is essential that teachers plan against any form of "cultural isolation" within an ethnically or religiously diverse class of learners, as feelings of isolation due, for example, to a student's belief, may result in disengagement by the student to the science lesson and therefore acceptance of the science theory being taught (p. 4-5). In some instances, this isolation can result in educational underachievement of cultural groups or individuals (Kiwan, 2012).

The notion of an instantaneously created world and created life on it, although having no scientific basis, is a "worldview" held in many cultures and religions (Reiss, 2008, p. 49, Reiss, 2011, p. 399 and Ingram, 2011, p. 239), for example belief in a creation of the universe and earth that occurred between 5000 and 7000 years ago (Mosley and Lynch, 2010). To encourage inclusion and participation during science courses multicultural science education suggests that students are given a narrative process and stories within science

that allows open and respectful discussion of alternative views within lessons, which may result in inclusion and not exclusion of students because of their culture and beliefs. Methods of teaching that involve no discussion of religious or cultural explanations of life and the universe may lead to feelings of exclusion within the class and rejection of scientific theories including the Big Bang and biological evolution. Cohen, Manion, Morrison and Wyse (2010) suggest lesson content needs to draw on a group's diversity of cultures, and "fairly represent these cultures" (p. 309).

Bruner recommends using a narrative process in teaching and that it is beneficial for learners to "play with ideas" (2004, p. 96). Reiss (2011) asserts that "one very rarely changes one's worldview as a result of a 50-minute lesson, however well taught …. [and] …. we can help students to find their science lessons interesting and intellectually challenging without being threatening" (p. 412). In this view for there to be effective learning support in the subject areas of the Big Bang and biological evolution, teachers and institution management should have the flexibility and background knowledge of cultures and religions to support students in these scientific areas, which can be controversial to the student, or parents, or to a wider group. Frost (2010) points out an additional complication where different personal cultural or religious beliefs of teachers "may put creationists and evolutionists side-by-side as colleagues" (p. 2). Tobin (2004) considers it is important that teachers are aware of the potential impact, positive or negative of cultural knowledge or religious beliefs on the learning of science. At the same time the teacher should ensure that in lessons it is made clear to all learners that the latest scientific findings support the Big Bang Model (May et al, 2012) and biological evolution (Daintith and Martin, 2010).

The Open University 'set book' for that university's PGCE in Secondary School Physics "Origin of the Universe" course states:

> For some of your students, these ideas may conflict with ideas that they receive from elsewhere, particularly religious ideas about creation and the Universe. While it is important to respect the right of individuals to hold such views, it should be made clear that the ideas you are putting forward as a science teacher are supported by a considerable body of evidence. Among scientists there is no controversy. (Osborne, 2011, p.231).

The Open University PGCE Biology course 'set book' suggests:

> For some students evolutionary ideas may pose problems because of religious views that they hold ……. One idea that ought to be avoided is presenting Creationism or Intelligent Design as a valid scientific alternative …… It might be helpful to emphasise that it is quite possible for the theory of evolution and belief in a Creator to co-exist together. Science and religious views are not, of necessity, mutually exclusive. If a school feel that this is an important issue to its students, then some form of collaboration between Science and Religious Studies might be developed. (Ingram, 2011, p. 239).

Ingram's (2011) suggestion that cultural beliefs and science are not mutually exclusive is supported by some religions, for example Roman Catholicism accepting the Big Bang as evidence for their deity and accepting that the latest scientific findings support the Big Bang theory (Spitzer, 2010 and May et al, 2012).

The view of Wellington and Ireson (2012) that alternative religious and cultural explanations should be included within science lessons is similar to Reiss (2011), that suggests "just because something lacks scientific support doesn't seem to me a sufficient reason to omit it from a science lesson" (p. 408), and if such questions and debates "arise during science lessons they can be used to illustrate a number of aspects of how science works …. shifting the discourse from controversy to sensitivity" of all students' cultures and beliefs (p. 411). This pre-known possibility of controversial debate within the teaching scenario suggests that "a good teaching strategy will pre-empt what the learner needs" (Laurillard, 2004, p.30). The collaborative elements including group discussion and inquiry involving all students, who may be from several cultures and religions, draws on theories of social constructivism (Driver et al, 2004), and may introduce the transferable skill of collaborative learning and peer negotiation. In this respect the multicultural science learning format may conform to Linn's view that "ideally, science instruction will ensure that students learn complex science in the context of inquiry" (2004, p. 9).

A teacher may successfully construct and scaffold the learning opportunity by building upon learners' existing knowledge and understanding as a collaborating group of students from several cultural backgrounds (Kyriacou, 2012 and Bowl, 2012). This form of cooperative

learning, that can involve areas of controversy, is shown in Petty (2009) to increase academic performance and assist the "classroom climate" of learners liking and respecting each other, and liking themselves in the form of self-esteem, to the extent that Petty views cooperative learning as "a main plank in equal opportunities policy" (p. 152), and therefore in the aim of fully inclusive learning, for all student groups that contain multiple cultural and religious backgrounds, thereby reducing or totally eliminating forms or feelings of cultural or religious isolation of any student. Reiss (2011) points out countries differ considerably in the extent to which they permit discussion of cultural or religious beliefs in their classrooms and therefore multicultural science education lessons involving evolution and the Big Bang theory may not be possible in some instances. In some countries teaching practices within science education can be detrimentally affected by direct government intervention, for example in Turkey where in 2018 the theory of biological evolution was removed from state school biology textbooks and was no longer taught in the majority of state schools (Jolley, 2018). Also, between 1949 and 1989, especially during the Cultural Revolution, the Chinese Communist Party and government officially dismissed both the Big Bang and Relativity, as they contradicted the infinite time and space of the dialectical materialism of communist ideology, resulting in state sponsored persecution of university physicists that supported the Big Bang theory and the theory of Relativity (Hu, 2004).

It could be suggested that the arguments against multiculturalist science education practice (Matthews 1993 and 1997, Jenkins 2001, Dawkins 2008) may be based upon education practice that existed before significant occurrences of multiple cultures co-existing within communities and schools, and might rely on out-of-date definitions of key terms that can now be contested, including a Standard Account of Science. Further, the approach of some supporters of universalist science education might be viewed as aggressive and blinkered, for example Dawkins (2008). Supporters of universalist science education may not be taking into consideration the cultural realities of modern times. Those who support multiculturalist education point to the significant benefits of this approach that include assisting in the delivery of "science for all", increasing scientific literacy, allowing the free discussion of socio-scientific topics, helping address educational underachievement of some cultural groups, increasing students' abilities to weigh up evidence while being encouraged to respect others that hold different views and to provide inclusive science education for all,

helping in the acceptance of science theories by learners (Petty 2009, Reiss 2011 and Wellington and Ireson 2012).

Where multiculturalist science education has been practiced it appears to not allow anything to count as science, but instead shows that Traditional Ecological Knowledge and Indigenous Knowledge can be included in curricula successfully. It may be suggested that multiculturalist science education is therefore relevant in contemporary science education, ensuring that cultural isolation of pupils and non-acceptance of scientific theories such as evolution and the Big Bang is avoided, while still providing students with the latest scientific evidence available. However, due to the significant differences in the legislation concerning education from country to country, the possibility of world-wide multiculturalist science education is impossible, for example in countries where only one dominant culture, religion or political movement is present, (Skehan, Nelson and Skoog, 2000). In countries where it can be legally practiced, multiculturalist science education may be seen to avoid cultural or religious isolation of pupils within science lessons, especially during culturally or religiously sensitive units of science modules or courses. In these instances, the use of universalist science education practice might be deemed detrimental to individual students, the learning group as a whole and to society, as it would not encourage science for all, nor scientific literacy, nor inclusive science education for all and may lead to scientific theories being rejected by individuals. The cultural realities of the modern world may point to the practice and advancement of multiculturalist science education and the lack of this practice in the past may be a contributing factor in the non-acceptance or rejection of the Big Bang and biological evolution in lifelong leaning by some individuals, as learning is culturally mediated (Vygotsky, 1978). However, care must be taken by teachers and lecturers that by undertaking multicultural science education they are not providing a legitimate means for creationism to be taught as science in schools (Skehan, 2000). Instead, using the narrative history of human knowledge, which has led to scientific knowledge, may be key to the practice of science education (Kenealy, 1989, Matthews, 1994, Klassen, 2007 and Evans, 2017), as “we are creatures of story”, (Evans, 2017, pg. xi):

> The challenge we face is to find genuine common ground …. while simultaneously recognizing and valuing what makes us different from each other. (Evans, 2017, p. 105)

Both universalist science education and multiculturalist science education, as differing teaching practices, have effects on the learning of science. The debate between adherers of the two teaching practices in science education can produce two differing science curricula depending on whether the writers of the curriculum and teaching method to be used adopts a universalist or a multicultural perspective.

2.3 Effects of religious belief on science learning and the conflict thesis

Another potential reason for the rejection of the two scientific theories is religious belief. Dawkins (2006), Dawkins (2008), Moore et al (2011) and Moore and Cotner (2013) echo the "conflict thesis" of Draper (1875) who suggested "the antagonism we witness between Religion and Science is a continuation of a struggle ……. the conflict of two contending powers, the expansive force of the human intellect on one side, and the compression arising from traditional faith" (p. 5). However, Lennox (2009, 2011a, 2011b), confirms that it is entirely possible and plausible for a theist to accept both the Big Bang theory and the theory of biological evolution, suggesting that various factors may be responsible for the rejection of some scientific theories, other than religious belief. Attenborough (2012) suggests evolution does not rule out the existence of God, as God could use evolution to bring about the natural living world. According to cognitive-by-product theory, humans are predominantly "born believers", and human brains are naturally inclined to find deity and religious explanations appealing (Hawking and Lawton, 2018, p. 169). Belief in God or religion may not automatically create a struggle with scientific theory. Tyson (2017) suggested in his presentation at Greensboro, North Carolina, that a major issue, instead of religion, is that citizens have poor scientific literacy:

> [citizens] are bad at science. Scared of math. Poor at physics and engineering. Resistant to evolution. This science illiteracy is a threat ……. [resulting in] a generation of people who do not know what science is nor how and why it works. (p. 1)

Established religions can be examined to confirm those that do, or do not, accept the Big Bang theory and/or the theory of biological evolution. One area of religious belief that can result in the rejection of both theories is adherence to the 6,000-year-old "created earth"

viewpoint, that originated in Christian Europe and uses interpolations from the Bible's genealogical lists from Adam to Jesus, given in the New Testament and similar lists given in the Old Testament (George, 2017). Religions can also be studied to assess those that have variations or degrees of acceptance or rejection of each theory. It is possible for each theory to be accepted or rejected independently of the other. In addition, it is possible for there to be significant variations of acceptance or rejection of each theory within specific religions.

2.3.1 Cognitive bargaining in Christianity

Hull (1985) points to the "cognitive bargaining" that has occurred in many religions where, "in order to maintain its plausibility within modernity, a religious belief system undergoes a degree of deliberate modification" (p. 11). In the 20th century for example, perhaps the most significant example of cognitive bargaining was the acceptance of the Big Bang and expanding universe by Pope Pius XII on 22nd November 1951, speaking at the opening of the *Sciences* to an audience that included Georges Lemaitre, a Belgian Catholic priest and professor of physics at the University of Leuven (Farrell, 2010), who had first proposed the concept of an expanding Universe (Lemaitre, 1927). The 1951 declaration, spoken by Pius XII, confirmed the acceptance of the expanding universe by the Roman Catholic Church and stated that:

> Present day science, with one sweep back across the centuries, has succeeded in bearing witness to the august instant of the *Fiat Lux*, when, along with matter, there burst forth from nothing a sea of light and radiation, and the elements split and churned and formed into millions of galaxies (Pius XII, cited in Farrell, 2010, p. 196).

For Christians and Jews, the book of Isaiah mentions God stretching and spreading out the heavens during creation three times, (42.5, 45.12 and 48.13, RSV Common Ecumenical Bible, 1973). Sagan suggests that "the Big Bang is our modern scientific creation myth" (Part 10, 2000), and Cox described it as our "wonderful creation story" (Cox, 2009), open to continuous examination and when necessary, amendment or even eventual rejection based upon any new or future scientific findings. Otto suggests the Big Bang theory "managed to bring the relationship between science and the Roman Catholic Church full circle" (2016, p. 96). The current Roman Catholic position is confirmed by Spitzer (2010) who states the Big Bang theory puts an end to Newtonian infinite time given by Newton (1686), and that time

came into existence with the Big Bang 13.7 billion years ago. For the Roman Catholic church this provides the point, at the start of time, of God's creation (Spitzer, 2010). The Vatican Observatory position is that the Big Bang and biological evolution can be seen as the "divine framework" by which God created the universe and life within it (Vatican Observatory, p. 1, 2024). The Roman Catholic church unofficially has held a broad spectrum of opinions within both clergy and members for centuries, confirmed as early as the early seventieth century by Galileo's discussions with Cardinal Baronio, that concluded the Bible teaches how to go to Heaven, and not how the Heavens go (Galilei, 1615). Gould (2002) suggests for most individuals any conflict between science and religion "exists only in peoples' minds and social practices" as it is possible to accept both the Big Bang and biological evolution while believing in and practicing many forms of religion (p. 3).

There is therefore evidence to support the "cognitive bargaining" theory of some religions given in Hull (1985) where there is deliberate modification, collectively by officials or individually by believers, or both. It can be suggested that when one compares the possibly anti-religious nature of Dawkins (2006 and 2008) with the view of Cox (2009) of the Big Bang being a modern creation story, there is a form of cognitive bargaining occurring in science, to counter the anti-religious thrust of Dawkins, that occurred at the end of the 20th century and beginning of the 21st century. However, on examination of Sagan (2000), that is similar to Cox (2009), it can be noted that Sagan's views were first published in Sagan (1980) pre-dating Dawkins (2006). The comparison of Dawkins (2006), Dawkins (2008) and Cox (2009) is not therefore an example of science undergoing cognitive bargaining, but instead illustrates the views and descriptive methods of individual scientists over periods of time, that appear to swing back and forth between anti-religious sentiment and seminal understanding, the latter provided by Cox and Cohen (2017):

> I am willing to recognise that romance, or wonder, or whatever the term is for that deep feeling of awe when contemplating the universe in all its immensity, is a central component of both religious and scientific experience, and perhaps there is room for both in providing the inspiration for the exploration of nature. (p. 57)

Despite Pope Benedict XVI's cautionary statement, given at his inaugural mass in 2005, that "We are not some casual and meaningless product of evolution" (Dixon, 2008, p. 80), the

current Roman Catholic position on biological evolution and the Big Bang is that members are free to accept either theory, on the basis of both being the plans and actions of God (Cusworth, 2014). However, Pew (2009), undertaken in the United States, confirmed that despite official positions from religious leaders, identification by an individual with a particular religion does not appear to determine acceptance or rejection of scientific theories. Instead, within religious groups, individuality appears to result in there never being a categoric and wholesale position, and individuals who identify with all religions taking part in the survey resulted in no single faith position proving 100% acceptance or rejection of the two scientific theories. In response to the question "Do you agree that evolution is the best explanation for the origins of human life on earth?", 58% of Roman Catholic respondents answered "yes" (Pew, 2009). This indicates not only that followers do not always accept the official position but also the individual may have variations of belief that cannot be answered in a simplified way, for example weather biological evolution was in some way inspired by or commenced by their deity. A similar question specifically involving the Big Bang was not undertaken in the Pew 2009 study.

The position of other Christian denominations varies. The Church of England's and the Anglican Communion's positions on the Big Bang theory and on the theory of biological evolution are that member are free to accept or reject either theory as they are both compatible with God's work and existence (Williams, 2012).The early acceptance by some members of the Church of England of biological evolution is illustrated by the agreement of the church for Charles Darwin's funeral to take place at Westminster Abbey, at which the sermon given by Reverend Frederic Farrar compared Darwin's scientific genius to Isaac Newton and stated that evolution was consistent with the actions of the Creator (Dixon, 2008, p.58). However, the Pew Survey indicates only 51% of "Mainline Protestants" and 24% of "Evangelical Protestants" in the United States consider biological evolution as the best explanation for the origins of human life (Pew, 2009). The percentage of rejecting biological evolution is highest among Jehovah's Witnesses, where only 8% agree that biological evolution is the best explanation (Pew, 2009), that is in accordance with their official view of rejecting biological evolution but accepting the Big Bang (Watchtower, 1998). Evangelical protestants provide examples of their rejection of both theories via literature, the internet and other material, for example the popular evangelical series "Astronomy" that aims to

convince viewers, via the internet, (www.creationastronomy.com, accessed 10.01.2024), and DVD (Psarris, 2012), of the "mistakes" in the Big Bang theory and biological evolution, by providing what it suggests is evidence for a Biblical created universe and created life on earth, within a Biblical timescale of thousands of years, and not billions (Psarris, 2012). The writer and presenter, Spike Psarris, is a science graduate who worked for the U.S. military space programme and who "was an atheist and evolutionist and now is a young-earth creationist and Christian" (Psarris, 2012). A similar multimedia example can be found in Gonzalez and Richards' *The Privileged Planet* (2010 and 2024). Although the internet can be criticized for providing a platform for misinformation, any restriction would disenfranchise individuals from the ongoing debate of who is right. Everyone should be allowed access to all views so that individuals come to their own conclusion.

Evans (2017) notes that fundamentalist religious leaders of Christianity, Islam, Hinduism and Buddhism have claimed that their religions' stories should be taken as literal facts rather than as symbolic truths, and that the religious congregations growing fastest are those that take this approach, especially in developing countries, where fundamentalist versions of these four religions are thriving. The fundamentalist congregations that are growing fastest rely on members avoiding the social exclusion or social marginalization that might lead to alienation or disenfranchisement within the religious group, by members conforming or matching beliefs to the group "norm". This can be in the form of pressure from religious leaders or peer groups to conform to fundamentalists versions of belief, where the member ignores scientific evidence in order to fit in with, and remain within, the religious group. This herd behaviour along-side the brain's own cravings for synchronicity are behaviours that are explained by the very evolutionary theory the fundamentalist belief attempts to counter (Raafat, Chater and Frith, 2009).

2.3.2 Islam

As in Christianity, within Islam there are advocates and Qur'an verses that can support both the Big Bang and biological evolution. Allah is described as the "expander" of the universe (Qur'an, 51:47), where "the heavens and the earth were a joint entity" (21:30), where Allah was in the universe while it was "smoke" (41:11), and where Allah then "separated them [heavens and the earth]" (21:30), forming "the sun and the moon, all [heavenly bodies] in

an orbit, is swimming" (21.33). Then Allah "made from water every living thing" (21.30) and created life "in stages" (71:14). However, other verses of the Qur'an indicate a created Universe and unevolved created humanity beginning with Adam (2:29, 3:190, 7:54, 10:3, 17:61 and 17:70). Among Muslim communities there is therefore a great variation between acceptance and rejection of both the Big Bang and biological evolution, indicated by the Pew data of 45% of Muslims in the United States that agreed that evolution is the best explanation for the origins of human life on earth (Pew, 2009). al-Mehri (2013) comments that:

> With the assistance of scientific advancement, we can now understand these verses in a new light which helps us piece together the cosmological puzzle. The miraculous nature of the Qur'an lies in the knowledge it contains. Its verification of scientific facts. (p. 718).

2.3.3 Other religions

When taking all faiths and beliefs into account, including for example Buddhism, Hinduism, and Judaism, an overall average of 48% of the U.S. population agreed that evolution was the best explanation for the origins of human life on earth (Pew, 2009). Another survey undertaken by Gallup in 2012 (Ra, 2016, p.13), examined the overall population of America, without splitting results into religious or other groups, and found that 46% believed God created humans in their present form, with no element of biological evolution, 32% believed evolution did occur but was guided by God, and 15% believed humanity evolved with no assistance from God. This illustrates the inadequacy of the Pew 2009 survey that only gave two possible options to its single question, yes or no. This study will observe if religious beliefs, which are not based on scientific findings, effect the levels of acceptance or rejection of the Big Bang and biological evolution. For example, "Creation science", that is an umbrella term used by the National Science Teachers Association to describe all theories and beliefs that purport to be scientific, holds various viewpoints ranging from a created earth 6,000 years ago to acceptance of elements of the Big Bang and elements of biological evolution, but where God not only started both but also continuously provides supernatural intervention, as life, in this view, shows evidence of "intelligent design" (Skehan, 2000, p. 1).

The interview questions used in this study needed significantly more breadth than the Pew 2009 survey and therefore allowed for all possibilities of opinion. This point will be taken further in the methodology chapter 3. In addition, differing levels of scientific literacy in the population are not taken into account in the Pew 2009 survey. In a 2004 Gallup poll 25% of those surveyed in America said they did not know enough about biological evolution to answer questions about it (Ra, 2016, p.13). If one quarter of the population is scientifically illiterate on the subject this will contribute to the rejection of scientific theories. In the same 2004 Gallup poll (Ra, 2016, p.13), 35% of respondence said that biological evolution was not supported by evidence, which may indicate further levels of scientific illiteracy.

2.4 Failings in science communication methodologies and academic disputes

Some science communication methodologies and academic disputes may also be potential reasons for the rejection of the two scientific theories. Science, if viewed as a socio-cultural practice, is adopted not exclusively upon whether it is true but according to how it is shared, for example, failings in science communication have resulted in the Big Bang theory and biological evolution being contested in the 21st century and illustrate the view given by Ziman (2002) of "the inability of science to arrive at complete certainty", that may even occasionally result in "grave social embarrassment" to scientists when hurried announcements are proved wrong (p. 254). This can lead to perpetual challenges and may lead to the rejection of scientific theories, including the Big Bang and biological evolution among some learners. Sherwood (2011) states that science controversies "seem to pit experts against one another on even the most basic facts" (p. 39). The examples of science communication that have resulted in the Big Bang theory still being contested do not just involve the overall encompassing umbrella of the theory being disputed, but importantly also involves crucial small elements of sub-theories being disputed. Crucial elements hold the over-arching theory together and if just one element is disproved the whole theory as a result comes into question (May, Moore and Lintott, 2012), in the same way as the smallest cog in a watch being removed stops the whole bigger mechanism from working. This

umbrella theory, being made up of several sub-theories that must each remain viable for the whole mechanism to work, is explained in Spitzer (2010):

> The General Theory of Relativity, Hubble's redshifts, Penzias's and Wilson's universal background radiation, black holes, quantum cosmology, inflationary theory, and a host of other ideas and discoveries have led to a grand scheme of universal origins called the "Big Bang theory". (p. 14)

Scientific disputes can also be state led, for example in Turkey in 2018 where a government created movement ensured that the theory of biological evolution was officially disputed and removed from state school textbooks and science lessons (Jolley, 2018) and the Chinese Communist Party dispute and rejection, between 1949 and 1989, of the Big Bang and Relativity, (Hu, 2004).

2.4.1 Announcements that are not peer reviewed

Controversies concerning the over-arching Big Bang theory itself may have had an effect on the acceptance or rejection of the theory in lifelong learning. In her article for *Science,* which discussed a 1992 un-peer reviewed announcement by Princeton University that questioned the nature of the Big Bang's fundamental evidence, Flam (1992) affirmed that "the combination of new data and unsettled theories should make for some exciting times in cosmology" (p. 30). News media subsequently took hold of the Princeton announcement in America to create articles including that the Big Bang theory was wrong, that the existence of God had been proven and that the Big Bang's inflation had been proven, (p. 31), depending upon the religious and other viewpoints of the journalists, editors and media owners concerned. In fact, the hurried announcement simply referred to details of uneven levels of cosmic background radiation, which had not been expected. To some scientists in the early 1990s, who still held hope for the alternative Steady State theory, this was evidence for dismissing the Big Bang theory, while for other scientists it was evidence for the inflationary element of the theory (Flam 1992).

This public announcement, that had not been through any peer review process, illustrates Wager's opinion of peer review being a hallmark of scientific credibility (2009), and where Grove (cited in Begley, 2007) is wrong in suggesting the peer review system is a modern equivalent to a Middle Age guild, with more sameness and less innovation. Further, peer

review stops unfounded claims by rogue scientists with agendas that can have detrimental effects on science communication, lifelong learning and society. It is true that some of these rogue scientists, with agendas, have got through in the past and used the peer review process to their own ends, for example Wakefield et al (1998). However, with the process now being more rigorous, because of past flaws being found and acted upon, this should be a rare occurrence in current and future peer reviewed publications.

Confusion among lifelong learners can also be caused by premature release of information to a popular audience, and science community-based controversies can spill over to public audiences, becoming a public controversy. In the view of Sagan premature, hurried and unchecked releases can be the result of scientists tending to be effervescent, uncontainable and having an indomitable compulsion to share new data (1997). However, the Big Bang theory and biological evolution have significant external dimensions where the theories are science-based but where there are social, cultural and especially religious aspects in human society, which can have a powerful influence and effect on the acceptance of the theories. The public non-peer reviewed questioning of elements of the Big Bang that may contributed to the dismissal of the theory by some learners included Inflation (Merali 2007), Gravitational Waves (Battersby 2017and McKee 2015) , Black Holes (Merali 2014, Peplow 2004, Kramer 2014, Mersini-Houghton 2014, Battersby 2017), Cosmic Microwave Background radiation (Nussbaumer and Bieri 2009 , Hoyle 1948,1983 and 1985), and the Higgs Boson (LHCP Conference CERN 2015, Lunau and Engelhart 2012, Lyre 2008 and Sidharth 2012). Penrose (2004) points out the effect of competition over collaboration, where hurriedly published and sometimes flawed research, which competes for scarce resources and grants, can create a "bandwagon effect …… where researchers fear to be left behind if they do not join in" (p. 1018). The British Academy (2007) suggests there is "no better alternative" and science "is better as a result of peer review" (p. ix). Grainger confirms that the peer review quality control process "remains the best system thus far conceived and implemented"(2007, pp. 5201).

2.4.2 Blogging and Web 2.0 technologies

Among the various hurried and incorrect public announcements that have been made were a number given by CERN, which was at times in competition with the Fermilab particle accelerator in the United States. These non-peer reviewed announcements included lone

blogging scientists, as in the case of Fermilab in 2010, (Rincon, 2010). Blogging is an example of the uptake of Web 2.0 technologies by scientists, that have significant drawbacks as well as positive outcomes. The term Web 2.0 refers to various changes that have occurred in the way World Wide Web pages are designed, made and used, specifically concerning the WWW technologies that encourage use, not just as a reference source, but to interact by contributing content using systems that connect related material (Chalmers, 2009). Web 2.0 sites often enable users to interact and collaborate with each other in contrast to Web sites where users are limited to passive viewing. Examples of these include blogs and social networking sites. These changing trends in use aim to encourage and increase creativity, information sharing and the function of the WWW for users. However, as in Fermilab in 2010, this ability for scientists to use blogs to make claims that have not been peer reviewed, nor even authorised, is a concern and again illustrates the points made by Wager (2009), the British Academy (2007), and Grainger (2007), in support of the peer review process. Fermilab was not alone in having problems with blogging, for example the CERN Director General Robert Aymra commenting that "in an age of blogs there are seemingly no secrets", in a newsletter following blogged rumours of a shut-down at CERN in 2008 (cited in Chalmers, 2009, p. 74).

Ziman (2002) is correct to suggest science has an inability to provide complete certainty in some instances, and challenges to the Big Bang theory may continue. The examples of science communication given in this section have resulted in the theory being contested. These examples confirm that the Big Bang theory is subject to problems of science communication that do not just involve the overall theory, but also its crucial sub-theories. The examples of areas of controversies in the theory itself, issues concerning inflation and gravitational waves, Black holes and the Higgs boson, have all resulted in the Big Bang theory being contested publicly. Announcements that were not peer reviewed have caused significant problems, as have the claims and counterclaims of scientists. Similar claims and counterclaims concerning the nature and very existence of Black holes, especially by such a world-renowned figure as Stephen Hawking have also proved problematic due to his increased use of media and books that were not peer reviewed in the years before his death (Hawking, 2018 and Hawking and Lawton, 2018). The claims and counter claims of the Higgs boson especially via Web 2.0 blogs have illustrated that a significant factor effecting all

these areas is when the peer review process is by-passed, in favour of hurried press-release or press conferences, and in addition when papers or books are published that have not been peer reviewed.

The examples given provide evidence to support the peer review process and warn against publication of papers that have not been properly peer reviewed, and hurried announcements, which aim to bolster the position and reputation of scientists and institutions and claim any possible discovery for themselves. Some of the examples also warn of the dangers of Web 2.0 technologies. Blogging has some positive outcomes of communication openness, but it also has significant drawbacks. These drawbacks are made clear by the Fermilab and CERN examples given where scientists can use blogs to make claims that have not been peer reviewed nor authorised. Changing trends in technology and use of technology may encourage and increase creativity and information sharing, but clearly there are also dangers to science communication as a result, which may have an impact on learning and acceptance of scientific theories. Scientists may find themselves involved in debates, often aired in public, which have political, social and ethical dimensions that can impact on funding and acceptance of research. Their work, in order to be funded, perhaps may need to have an impact on wide-ranging audiences that will include local and national communities, groups and organisations. Such work and findings may well be overlooked in public debates, sometimes instigated by media reports, unless they use and work with media professionals. In this context journalism is therefore an important tool in the dissemination of information that scientists want to publicise (Ward, 2008). However, this reliance upon non-specialists may compromise the integrity of the message and may result in rejection of scientific theories.

2.4.3 Models of science communication

The role of journalists can be illustrated using the transmission model of science communication based upon the linearity of information flowing from individual to individual (Leach et al, 2009). The transmission model illustrates and highlights features of sender, message and receiver. Perhaps because it is intuitive, and relatively easy to apply, Leach et al suggests the transmission model is the most widely used model (2009). Alternatives to the transmission model include the ritual model, that emphasises the communal sharing of information within a cultural context, (where science might be seen as a socio-cultural

practice), as opposed to an emphasis of linearity, by emphasising aspects of act, purpose, scene, agent and agency, and in the more sophisticated media studies model (2009, p. 145). In this model "sender" becomes "producers", "message" becomes "texts" and "receivers" becomes "consumers", where producers are noted to be mainly in influential institutional settings, where science communication is mediated, where there are often multiple and complex producers, multiple texts and consumers, and where consumers are part of multiple communities often involving complex social interaction. Science communication via journalists can often be accurate but not necessarily impartial, and the latter may well be influenced by scientific and social consensus, concerns of the day and by editors and owners. Further concerns of trustworthiness are found in the strategic management of scientific information for possibly unseen purposes, including "spin". An example of this, for political ends, is found in the Windscale controversy (Smidt, Scanlon and Holliman, 2011). Online journalism and reporting use the same delivery methods as social media where social networking, interactivity, personalisation and the ability to post alternative comments to articles that journalists have written is becoming popular. An example is found in the BBC news and science coverage, where at the end of some on-line articles there is an ability to post comments, or alternative views, to that given by the journalist (BBC News, 2015). This can result in the journalist's work not being the end of the messenger process, but the start of a public debate on-line. This is not the case for radio journalism where there is often little scope for debate following the message being delivered (Redfern, 2009).

Redfern (2009) confirms there is a changing nature in sourcing science stories, where today there is a requirement for topicality. Some news becomes part of an extended public debate, as in the case of Dolly the sheep (Jensen, 2008), while others remain overlooked. In the former, the issue has religious, cultural, psychosocial, and ethical perspectives. Science stories are often selected by journalists and editors for what is judged to be "of interest to the audience, relative to what else is leading the news agenda" (Holliman, 2007, p. 277), and relies on the experience and intuition of the media professionals, that can include the journalist, editor and owner. The news value of what is considered by journalists and editors to be of public significance therefore becomes a key application in the process and following selection, science stories can be shaped by journalists by increasing awareness, using for example a 'punchy' headline. On occasions public relations officers from institutions can

offer “packaged” news stories that require little editing or alteration (Ward, 2008) and reduce the amount of true investigative journalism being undertaken. Science news can be promoted by originating organisations to put across the originators intended message, with little need for journalist or editor alteration (Cottle, 2003). Although the originating scientist or organisation does not have total control of what is finally represented by the journalist, the employing of media professionals and public relations specialists can have an impact. However, audiences can challenge the fourth estate function of science news media by the fifth estate, social media, that is free of norms and conventions, illustrating that audiences are consuming science media in sophisticated and challengeable ways, for example via alternative web-based accounts of science, such as that given by *IFLScience.com* (accessed 15th September 2024). The fourth estate in this context is defined as conventional news media or press and the fifth estate is defined as social media and non-mainstream media, both as extensions to the older concept of the first three traditional estates of the realm of clergy, nobility and commoners (Al-Rodhan, 2007).

Journalists need the ability to sift through the prolific amount of news information concerning science using both proactive and reactive skills. Reputable journalists will confirm that sources are credible before using them, using among many sources peer-reviewed journals and science websites, which are example of where digital technologies play an important and essential role in promoting science to newsrooms. Science news can therefore be sourced in many ways. For example, promotional strategies are seen as attractive to different newsroom individuals and groups. These strategies use information subsidies that control access and use of information. As media is competitive and costs are high, promotional strategies are useful to editors and owners, where investigative journalists are expensive and ready-made stories are ideal for business purposes (Holliman, 2007). Information subsidies are disseminated by online press releases with embargos on time sensitive information. Examples of press release are available at AlphaGalileo.org (accessed 15th September 2024), and EurekAlert.org (accessed 15th September 2024). Information subsidies create a symbiotic relationship that benefits many, including academic journals, which increase their profile, and journalists that increase their status, as key sources of information. Trench (2009) confirms that the Web is the main source of science news for journalists, scientists and the public, resulting in mainly desk bound

journalism. In addition, the journalist becomes a transmitter rather than an interpreter and critique.

Ward (2008) suggests an interventionist approach of coordinated and strategic methods is necessary, as he contends that scientists and their work will be overlooked unless they use media and those employed within it, as an essential source of disseminating information to public audiences and potentially, with good relations, help shape and frame public scientific debate. By the very nature of some topics, for example climate change, Ward (2008) suggests some areas of science are controversial and contestable in several ways, including politically, ethically, culturally and religiously. Therefore, Ward suggests scientists must often actively promote their work and evidence. This may lead to science communication not being impartial, for example concerning climate change. Ward points out that media professionals can push impartiality over accuracy, resulting in unscientific positions obtaining equal coverage to scientific consensus, for example the coverage at the time given to both *An Inconvenient Truth* (Guggenheim, 2006) and *The Great Global Warming Swindle* (Durkin, 2007). Therefore, coordinated and strategic methods must be used by scientists in science communication, and this will mostly justify any counter argument of reduced impartiality. Science communication via journalists and media maybe sometimes partially inaccurate and not impartial due to the very nature of having a mediating factor in the middle, between scientist and public, and this can have a direct effect on the acceptance or rejection of scientific theories, including Climate Change. In addition, such scientific disputes are often fuelled by journalists and media, as Bari confirms such disputes and public arguments form part of the human condition where, "academic disputes can be bitter and undignified, but victory offers the delicious taste of *Schadenfreude*" (2017, p. 28).

Unlike the Big Bang theory, the theory of biological evolution, due to the much longer period that is has been known to the general public and due to its significant level of evidence available to experience, via sight and even touch in museums, is considered more settled and beyond challenge. As a result, it is rare for challenges to the theory of biological evolution to make the public headlines, with the exception of one alternative theory from the 20th century, namely Panspermia (Arrhenus and Borns 1909 and Hoyle 1955) detailed in the next section.

2.5 Other theories as alternatives

In a socio-cultural model of science, truth does not pre-exist independently and as knowledge becomes outdated it remains part of the received cultural inheritance, for example, the two peer reviewed theories proposed in the twentieth century as alternatives to the theories of the Big Bang and biological evolution: the Steady State theory of the universe and the theory of Panspermia. Both were proposed by, among others, Hoyle (1948, 1955 and 1983). The Steady State theory proposed the universe had no beginning and has no end (Hoyle, 1948). The Panspermia theory proposed, among several variations, that the first forms of life on earth originated and evolved in other parts of the universe and after arrival on earth, via comets and meteorites, continuing to evolve (Arrhenius and Borns 1909, Hoyle 1983, Hoyle and Wickramasighe 2000 and Wickramasinghe 2011). Hoyle's Steady State theory was an updated version of the older discredited "Static Universe theory" and "Changeless Universe theory" of the early twentieth century (Eddington, 1933, pp. 44-45). Hoyle's theory of Panspermia was based on evidence suggested in two papers (Hoyle and Wickramasinghe, 1978 and 1979), together with Hoyle's and others original suggestions of the possibility of Panspermia given in Arrhenius and Borns (1909) and Hoyle (1955). Both theories are no longer considered valid in the scientific community due to the lack of evidence, and the alternative significant body of evidence for the Big Bang and biological evolution. The lingering effect and recollection of the Steady State theory was noted in academic circles by Barrow (1994), confirming incidents of rejection of the Big Bang theory:

> Talk to anyone who is not an astronomer but who has a passing interest in the subject and you may find that the mention of the big-bang theory provokes a recollection of something called 'the steady-state theory of the universe'. In fact, the steady state theory ceased to be of interest to cosmologists about thirty years ago, but it lives on in the popular mind nonetheless. (p.31).

Barrow (1994) suggests that in the scientific community the Steady State theory was rejected in the 1960s, however when one compares the writings of two internationally

respected cosmologists of the 1970s, Sciama and Narlikar, it is evident that in that decade the debate was far from over, with Sciama (1975) stating "the Steady State model is attractive in many ways" (p. 117), and Narlikar (1977) stating:

> I have avoided the temptation of coming to definitive conclusions like 'the Universe had a big-bang origin' or 'the Universe is in a steady-state'. In my view observational astronomy has still a long way to go before we can draw such conclusions. (p. 245).

The lingering impact of the Steady State theory will only affect the acceptance or rejection of the Big Bang theory and not directly on the acceptance or rejection of the theory of biological evolution. This lingering effect still occurs today as those in their fifties and over may still recall being taught at school and at university the Steady State theory. Some of these individuals may still consider it valid and may inform younger generations of this in social settings. It is still possible via BBC iPlayer to listen to the biggest exponent of this theory confirming in 1950 that:

> Perhaps like me you grew up with a notion that the whole matter of the universe was created in one big bang at a particular time in the remote past. What I am going to tell you is that this is wrong. (Hoyle, 1950, re-released 2015).

Stephen Hawking confirmed that he too once considered the Big Bang theory to be fundamentally wrong and believed the Steady State theory to be correct for the first two years of his doctoral research (Hawking, 2013). Indeed, Hoyle was still successfully writing peer reviewed papers up to 1990 that dismissed the Big Bang theory (Hoyle 1990 and Arp, Burbidge, Hoyle, Narlikarand Wickramasinghe, 1990), and he publicly rejected the Big Bang theory till his death in 2001 (Singh, 2004). Hoyle's dismissal of the theory can be understood by examining Hawking and Mlodinow (2010), that confirms a key part of the Big Bang theory is problematic, as the "Standard Model" of particle physics that helps explain the events within the Big Bang theory "contains dozens of adjustable parameters whose values must be fixed to match observations, rather than being determined by the theory itself" (p.52).

Individuals are not only influenced by science information obtained via information technology in the present. Many peoples' views on issues may well have been formed in their teenage years, for instance by reading schoolbooks or encyclopaedias. As late as 1980 the ninth edition of the most widely read children's encyclopaedia in the UK, *The Hamlyn Children's Encyclopaedia*, designed for 10–15-year-olds (Bailey, 1980, p. i), gave equal credibility to Hoyle's Steady State theory as to Lemaitre's Big Bang theory:

> There have been many theories put forward to explain how the universe began, some fanciful and far-fetched, others reasonable and basically sound. The two main theories widely held today are totally different. One assumes that the universe began at a certain time in the past and reached its present state as a result of a gigantic explosion. This is the "Big Bang", or evolutionary, theory. The other assumes that the universe is the same now as it always has been and always will be. This is the "Steady-State" theory. (Bailey, 1980, p.127).

As a result, a young child reading this in the 1980's may well still be influenced today, as an adult, by the book and its contents, despite the abundance of evidence supporting the Big Bang theory and its sub-theories. In addition, this book was popular in children's sections of pubic and school libraries, both primary and secondary, as well as being purchased for home reference. The 1980 edition was the 9th edition of the popular book, and the print run requirement would have been significant for it to have undergone and sold nine editions from 1971 to 1980, all of which contain the same statement concerning the Big Bang and Steady State (edition copies 1971 and 1980 held at the British Library, accessed in the Readers' Room 29th January 2018). This encyclopaedia is still found widely in second-hand book shops, public and school libraries, and the researcher came across a copy at a holiday cottage in 2015 for visitors to read among other books.

The Collins Concise Encyclopaedia, that was described by the editor as "completely new, providing a record of all fields of human knowledge and experience in the final quarter of the 20thcentury" (Mallory, 1984, p. v), is a further example of an influential reference source

in homes, schools, universities and public libraries that as late as 1984 continued to give equal credence to the Steady State theory and the Big Bang theory:

> Theories of the origin of the universe include the Big Bang and Steady State theories ……. The Big Bang theory, in cosmology, is a hypothesis that the universe evolved from a highly dense concentration of matter which underwent an enormous explosion ……. Opposed by the Steady State theory ……. that the universe is in a steady state. Although the universe is expanding, matter is continuously created and so no overall change can be detected. In this theory, the universe has no beginning or end. (Mallory, 1984, pp. 68, 144, 536)

Both encyclopaedias can still be purchased today via the internet, providing evidence that discredited and outdated scientific theories can still be read as valid by an unsuspecting audience, both older and younger (www.amazon.co.uk, accessed 31st January 2024). As with these encyclopaedias, the Penguin Dictionary of Physics of 1986 gave equal article space to both the Steady State and Big Bang theories (Pitt, 1986).

However, of greater concern while undertaking the literature review was noting that the University of Reading's teacher training resource library, used by current PGCE students, contained a regularly used copy of the "New Edition" Macmillan Children's Encyclopaedia that states:

> No one knows how the Universe began and where it will end. Some astronomers say that the Universe has existed forever and will never end [Steady State theory] ……. Other astronomers think that the Universe formed at some point in the distant past [Big Bang theory]. (Sealey, 1986, p. 290).

If post graduate students training to teach in 2024 are using such outdated science summaries there is little wonder that in society the Steady State theory persists. Cox noted the similarity between old history theories and old science theories lingering for long periods and occasionally resurfacing in cultural inheritance, via out-of-date textbooks (2003). Cox (2003) provides an example of where pro-confederacy and slavery apologist textbooks were still in school, universities and public libraries into the 1970's in the

southern States, which contributed to beliefs in confederacy pro-slavery views, still held and perpetuated by some in areas of the United States today. It is therefore not just science that suffers from the lingering effects of old theories and opinions.

Singh (2004) confirms Hoyle continued to publicly dismiss the Big Bang theory in favour of Steady State models until his death in 2001, when shortly before his death Hoyle stated:

> I think that it is fair to say that the theory [Steady State] has demonstrated strong survival qualities, which is what one should properly look for in a theory ……Theories are never proved right. The best they can do is survive. (p. 440).

Hoyle had proposed Panspermia, also sometimes called the Cosmic theory of ancestry, and Cosmic Evolution among other names, as an alternative to Darwin's theory of evolution (Hoyle, 1983, p. 110). This theory states in some versions, that the first forms of life did not originate and start to evolve on earth and instead originated in other parts of the solar system, galaxy or universe, and arrived on earth via comets and meteorites, only then continuing to evolve into new life forms (Hoyle, 1983). Hoyle proposed this theory as an alternative to "the Gospel according to Darwin …. [that was] …. like a superstition on so-called enlightened opinion" (Hoyle, 1983, p. 26), and was based on the difficulties of explaining the origin and existence of DNA and the first living things that deriving from non-living building blocks. The theory was not accepted within the scientific community, however Hoyle's publication in 1983 of *The Intelligent Universe, A New View of Creation and Evolution* resulted in a version of Panspermia being disseminated directly to public audiences and students, without peer review. One current popularist proponent of Panspermia is Silver (2017), whose work on the theory is not peer reviewed and the web site *ancestryofman.com*, that suggests, with Silver, that although all non-human life evolved on earth, humanity was in some form transported to earth from other planets 50,000 to 60,000 years ago (www.ancestryofman.com, accessed 19.03.2024). In addition, Hoyle's co-researcher Wickramasinghe co-authored, (as one of 33 scientists that still support the theory), a paper on an updated version of Panspermia proposing virus-bearing comets and detailing the problematic evolution of the octopus (Steele et al, 2018). These various theories were publicly enhanced by the incorrect claim by some NASA scientists that meteor ALH84001 contained fossilised bacteria, subsequently dismissed by peer review (Hawking

and Lawton, 2018). This meteor claim was similar to earlier claims concerning three other meteorites, named Murchison, Orgeuil and Ivuna, that appeared to contain evidence of basic life forms living in space, which were subsequently disproved (Hoyle, 1985). Most recently the Panspermia theory was suggested as far-fetched, but possible, by Packham and Cohen (2023a and 2023b). Although these various theories of life on earth's cosmic ancestry are only supported by a relatively low number of scientists (Steele et al, 2018), life in the form of fundamentally basic microbes, (not complex life), could indeed have emerged, if only for a small period of a few million years in the vastness of the universe, approximately 15 million years after the Big Bang when the cosmic microwave background would have been at the right temperature to make the whole universe a life-friendly zone, as the background cooled from its original intensity to its current faint remnants, according to Battersby (2017). However, there is no evidence that any potential basic life forms from this early period in the history of the universe seeded on earth when it eventually formed billions of years later. A version of the theory is the theory of Directed Panspermia that proposes that microorganism or more advanced life was seeded deliberately on earth from other planets, proposed by Shklovski and Segan (1966), Crick and Orgel (1973) and in Crick (1982). Of the three only Crick and Orgel (1973) was peer reviewed before publication.

2.6 Science fiction and popular culture

A further potential explanation for the rejection of the two scientific theories may be found in science fiction and popular culture. Without any significant evidence to support the Panspermia theory it declined in popularity, until in science fiction the Star Ship USS Enterprise, under Captain Pickard, found evidence to suggest humanity had been seeded across many star systems, including on earth, thereby bringing aspects of the theory back to life in popular science fiction culture (Frakes, 1993). In addition, the fictional existence of life on asteroids was popularised by Star Wars: The Empire Strikes Back, Episode V (Lucas, 1980), portraying large snakelike creatures living within an asteroid. Similarly, the film Evolution (Reitman, 2001) centres on alien life-forms coming to earth on a meteorite, upon which they had been living and evolving in space. The possibility that viruses, which did not originate in our solar system, travelling to earth on asteroids and surviving entry through earth's atmosphere and landing to infect humans is found in the popular comedy series The

Big Bang Theory (Lorre, 2018, S12, E14). Further in popular culture the premise behind the Alien franchise prequel, Prometheus, is an anti-Darwinian theory that the human race did not evolve on earth from other primates but was instead engineered and deposited on earth by life forms from LV-223, in a distant solar system (Scott, 2012). This anti-Darwinian premise is continued in Alien Covenant (Scott, 2017), and the subsequent television production of Alien Earth (Scott and Hawley, 2024). The storylines of Superman are inconsistent regarding the biological and evolutionary link between his species and humanity, however in the storyline of *Man of Steel,* humans and Superman may have shared a common ancestor that ceded humanity on earth (Snyder and Goyer, 2013). The fictional pathologist that performed the autopsy of Abin Sur suggests his species of the Guardians of the Universe Green Lantern Corps possibly shared a common ancestor with humans, who did not therefore evolve on earth (Campbell, 2011). Panspermia theory is referenced in the 2024 production of the 3 Body Problem (Kullback and Shaukat, 2024). The effect of popular culture has further entered the realm of questioning what is science and what is the scientific method via the scenes of discussion and ridicule of non-physics subjects, including biology and geology, given by characters in The Big Bang Theory (Lorre and Prady, 2019). The discussions and divisions noted in science, including theories that counter the Big Bang and biological evolution, has thus migrated from the realms of scientists and academics to the general population, via fiction and popular culture.

This study will seek to establish if the Steady State theory and versions of the theory of Panspermia still effect the acceptance or rejection of the Big Bang theory and theory of biological evolution. Other alternative theories to the Big Bang detailed in Silk (1989), that included the theories of Tired-Light, Arpian Objects, Antigalaxies, Variable Gravitation and Variable Mass (decreasing atomic dimensions), and the theory of a repulsive force of distant galaxies (Whipple, 1968), were never seriously considered by the scientific community and did not result in public discourse (Silk, 1989), resulting in the Steady State theory being the main alternative to the Big Bang, and Panspermia being the main alternative to biological evolution in the 20th century.

Sherwood (2011) confirms the potential timescales of new theories becoming widely accepted in the scientific community and the overlap that occurs in their being accepted by a “public” audience. His paper takes the examples of heliocentrism, general relativity and

global warming and the lengthy periods it takes for, firstly scientists and subsequently the general population, to accept new scientific theories as proven. Even Einstein once considered the then new Big Bang theory to be wrong during its infancy, preferring his own "static universe" (Einstein, 1917). When Einstein eventually altered his general theory of relativity, he called his previous position the "greatest blunder" of his life (Otto, 2016, p. 95). The theoretical physicist Max Planck confirmed the lingering effects of old theories are common in the history of science as, in his view, "a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it" (cited in Thompson, 2017, p. 60), a position evidenced in Mosley, "as so often in science what happens is people that hold the old views slowly die off" (2010, part 1), when he commented on the near century between Copernicus (1543) and Galileo Galilei (1632). This study will aim to check if younger lifelong learners do have a greater acceptance of both the theories of the Big Bang and evolution than older lifelong learners, and if so why.

2.7 Avoidance of cognitive dissonance

A potentially relevant behaviour that may help explain the rejection of both theories is the avoidance of cognitive dissonance. A fear if either theory is proved true may be an example of cognitive dissonance. Cooper confirms that cognitive dissonance is "based on an idea of what occurs inside people's heads [not outside them]" and where "inconsistent cognitions cause tension, the tension is arousing and experienced as an unpleasant state, and people are driven to reduce it" (2007, p. 42). The theory is based on the work of Festinger (1957), who noted that when an individual holds or is aware of two inconsistent cognitions the resulting dissonance motivates the individual to reduce dissonance and achieve consonance by either adding new elements to one cognition or avoiding social situations and contradictory information. Tedeschi and Rosenfeld (1981) and Schlenker (1982) also note that the need to reduce dissonance and achieve consonance may be an attempt to avoid social anxiety and embarrassment or protect a positive view of the individual's own identity. Wolpert (1993) examines the fear of science and fear of scientific theories and proposes that the sometimes counter intuitive and the "unnatural nature of science", when combined with a lack of understanding among non-scientists is linked to "a fear of and even hostility"

to science and science theories (p. ii). However, this may not explain when the fear occurs among internationally respected scientists, as opposed to non-scientists. Hoyle himself provides evidence to support the suggestion that fear of the implications and consequences of the theories can result in their rejection by some individuals and groups, including scientists. Several paragraphs were added to his book *The Nature of the Universe* when one compares the 1950 edition to the 1960 edition, that mainly concerned additional scientific information. However, one of these additional paragraphs details Hoyle's personal psychological difficulty, which resulted from never having rejected the Steady State view, despite its eventual demise. This is given quite openly in the 1960 edition:

> Without continuous creation [part of the Steady State theory] the Universe must evolve towards a dead state .... the outcome is always the same .... With continuous creation, on the other hand, the Universe has an infinite future in which all its present large-scale features will be preserved. (p. 117).

It is possible to argue that there are psycho-social reasons to accept and support either theory. For example, the Big Bang gives a point of creation in time for those that believe in a deity. Alternatively, the Steady State theory avoids the "dark cold death" of the Universe. This "dark cold death" of the Universe, that was a direct element in Hoyle rejecting the Big Bang and expanding universe, is described more recently as "the cosmos will die; every single one of the hundreds of billions of stars in the hundreds of billions of galaxies in the Universe will expire, and with them any possibility of life in the Universe will be extinguished" (Cox and Cohen, 2011, p.239). The psychological impact of accepting the full implications of the Big Bang were also noted by Carl Sagan in the ground-breaking series *Cosmos*, "Modern cosmologies may not be altogether to our liking ……. the death of the universe may seem a little depressing" (2000, Part 10). Fear, enmeshed within an individual's life history, which results in the rejection of scientific theories is consistent with views of the theoretical physicists David Bohm as lead author in a joint essay:

> If we look carefully at what we generally take to be reality we begin to see that it includes a collection of concepts, memories and reflexes coloured by our personal needs and fears ……. It is extremely difficult to disassemble this mixture. (Bohm, Factor and Garrett, 1991, p. 1).

The science education resource Kurzgesagt confirms the psychological impact of accepting the Big Bang's dark cold death of the universe in their *Three Ways to Destroy the Universe* video used by some science teachers, initially in Germany but now worldwide via YouTube, that concludes some students prefer a "crunch and bounce", (expansion then contraction in a never-ending cycle), as it is less upsetting to them (Kurzgesagt, 2014). Most recently Packham and Cohen (2023a and 2023b) suggest areas of evolution and cosmological change involve uncomfortable truths, confirming these feelings of unease about both theories are not specific to the early decades of the theories propagation, but continue beyond, as the upset appears hard wired in the human condition.

Cooper suggests "if we take away the discomfort, there is no dissonance" (2007, p. 61), and "according to self-affirmation theory, they can do almost anything to make it right" (2007, p. 92). Avoidance of cognitive dissonance can result in an individual seeking "validation in having the world believe them" (Cooper,2007, p. 5). Perhaps this helps explain Hoyle's behaviour and beliefs. Hawking and Lawton (2018) suggest one of the major reasons Hoyle and supporters of the Steady State theory rejected the Big Bang theory was because the Big Bang might be seen to require a God to start it all off:

> At the time many scientists were unhappy with the universe having a beginning because it seemed to imply that physics had broken down. One would have to invoke an outside agency, which for convenience one can call God, to determine how the universe began. They therefore advanced theories in which the universe was expanding at the present time but didn't have a beginning. Perhaps the best known was proposed in 1948. It was called the Steady State theory, and it suggested that the universe had existed forever and would have looked the same at all times. (p. 2)

A possible further subconscious, or conscious, reason for Hoyle's public dislike of the Big Bang model was that he himself named it, in an attempt to belittle it. The term was first aired by Hoyle, in perhaps a belittling manor, in 1950 on the BBC in a series of five lectures given at prime time on Saturday evenings at 8pm, with transcripts published in the BBC weekly *Listener* magazine, which made Hoyle a public celebrity (Hoyle, 2015). Singh comments that "'Big Bang' turned out to be a short, punchy and memorable title for the theory of creation, yet it was invented by the theory's greatest critic" (2004, p. 483). Hoyle

scathingly wrote “To claim, however, as many supporters of Big Bang cosmology do, to have arrived at the correct theory verges, it seems to me, on arrogance” (cited in Singh, 2004, p. 483).

Between the dates of the 1950 and 1960 editions of *The Nature of the Universe* Hoyle’s personal feelings of insecurity were confirmed in 1953 when he wrote *A Decade of Decision.* Significant portions of the work describe Hoyle’s views of “economic and physical insecurity” on both a personal level and in terms of the direction of society (1953, p. ix). This personal work supports the possibility that Hoyle continued to reject the dark cold death of the Universe, not on the basis of science, but on the basis of fear of the theory’s implications, resulting in his continued promotion of the Steady State theory in his later popular works, including *Astronomy* of 1962 and *The Intelligent Universe* of 1983. Sagan suggests “cosmology brings us face to face with the deepest mysteries, with questions that were once treated only in religion and myth” (2000, Part 10). If one scientist had the most significant effect on the rejection of the Big Bang theory by individuals and groups, Fred Hoyle is a strong candidate, with the most public persona and popularity, used by him to promote the Steady State theory. Individuals now in their fifties and older who read Hoyle’s popular science writings in their late childhood and early adulthood may still hold views supporting the Steady State and rejecting the Big Bang theory.

In addition, Hoyle was not the only internationally recognised expert in this area that popularised the Steady State theory on Television in the 1950s. Lyttleton in 1955 produced a series of six programmes, also for the BBC, entitled *The Modern Universe* that supported the Steady State theory over the Big Bang theory (Lyttleton, 1957). In the subsequent publication of the series scripts Lyttleton confirms that his preference for the Steady State theory is due to “aesthetic considerations” and that the Steady State theory gives “greatest sources of appeal” without the need for the universe to have a creation or beginning and no need for an eventual dark cold end (Lyttleton, 1957, pp. 204-205). This confirms that factors, other than scientific evidence, influenced some notable internationally recognised scientists to reject the Big Bang theory in the twentieth century. The feelings aroused by astronomy among scientifically literate individuals, some feelings of which are not scientifically based, are termed by Lyttleton as “cosmic emotion” (1957, p. 5). Several other scientists and academics have written of their sometimes depression concerning modern cosmogony and

astrophysics, for example Heilbron (2015), who writes “the universe as interpreted by modern physical science is horrifying” (p. 197), and Weinberg (1993):

> The more we know about the universe, the more it is evident that it is pointless and meaningless …. [however]…… the effort to understand the universe is one of the very few things that lifts human life above the level of farce and gives it some of the grace of tragedy. (pp. 154-5)

Pyke (1963), a contemporary of Hoyle, commented that science “can only be accepted by the brave” and that scientists “cannot claim the security of other men” (pp. 179-180), often resulting in feelings of unease among both scientists and non-scientists. This view is also held by Wolpert (1993), “Science can be quite uncomfortable to live with – at least for some people” (p. xiv).

Fear may also exist among some learners for the implications of the theory of biological evolution. For example, a deeply held religious view of the unique status of humanity as the God created over-seer of all other life on earth, is challenged by the concept of humanity given in the theory of biological evolution. Lifelong learners who hold this religious view of humanities special status on the earth and in the universe may have a fear of the implications, if true, of biological evolution upon the status of humanity in the universe and upon their faith. Mosley and Lynch (2010) suggest modern astronomy results in the human race, and its concerns, becoming cosmically insignificant. Gould (2002) suggests science theories like biological evolution and the Big Bang “cut closest to the psychological bone of our deepest hopes and fears” (p.108). Sagan (1997) gave a personal perspective “for me, it is far better to grasp the Universe as it really is than persist in delusion, however satisfying and reassuring” (p. 12). Mosley and Lynch (2010) suggest for many other individuals the Big Bang and biological evolution are as unsettling today as was the earth going round the sun to contemporaries of Galileo. Bronowski attempts to counter some of these feelings by suggesting humanity still has a special place without the need for religion, as humans are unique among the animals, in that humanity alone can substantially change its environment, including devastatingly for all life forms (1973).

In the 20th century Hoyle was also one of the most noticeable critics of biological evolution and was a house-hold name in popular science, openly doubting the credibility and evidence of Darwin’s theory of evolution, and of life forming from non-living matter, stating in his

view “the likelihood of the formation of life from inanimate matter is one to a number with 40,000 noughts after it ……. It is big enough to bury Darwin and the whole theory of Evolution” (Hoyle, cited in Singh, 2004, p. 350). Hoyle was writing papers up to 1990 that openly cast doubt on both biological evolution and the Big Bang theory, and on two occasions combined both topics in a single publication, (Hoyle, 1983), and peer reviewed paper, (Hoyle, 1990). Although Hoyle did not follow any religion and although he had a personal dislike of the Book of Genesis, (Hoyle, 1994), this is countered by his support for the rights of religious people to believe and live unjudged by others. For example, in his autobiography describing his friendship for “two of my best friends in the village [who] were Catholic, a boy of about my own age and an older girl” who he would help and protect from the local population’s “evil intent” to them, simply because of their religious faith (Hoyle, 1994, p.37). In later life he fought against public and private attempts at singling out or humiliating scientists who held religious beliefs, suggesting:

> It were better for a scientist to have a millstone hung around his neck than that he should admit to such a belief – yea, verily. If he does so, his papers will be rejected, he will receive no financial assistance in his work, the publishers of his books will receive threatening letters, and his children will be waylaid on their way home from school. (Hoyle, 1994, p. 257).

Although not having any religious belief he continued to reject elements of biological evolution, writing “life is a cosmic phenomenon and not the outcome of a number of highly improbable events that took place locally here on the Earth” (Hoyle, 1994, p. 395). His arguments against biological evolution are used by Jehovah’s Witnesses in their arguments for rejection of the theory (Watchtower, 1998). However, in his autobiography he confirmed that he did not believe in a Christian God, but he did not describe himself as an atheist and instead attempted a balance; “today we have the extremes of atheistic and fundamentalist views, and it is, in my opinion, a case of a plague on all their houses” (1994, p. 421). Further he continued his support for those scientists that held religious beliefs into the final years of his life, “the crude denial of religion that became prevalent among so-called rationalists …… [has] no real intellectual value” (Hoyle, 1994, p.414). In the 1980s and 1990s Hoyle supported the idea of a “supercalculating intellect” and a “purposive scenario to which the universe conforms” where “a common-sense interpretation of the facts suggest that a super

intellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces" (Gingerich, 2005, p. xi). His popularity as a plain-speaking Yorkshireman from a working-class background who, by shear hard work became a Cambridge Professor of astronomy, propelled his personal disbelief in both the Big Bang and biological evolution into the homes, schools and universities of the mid-20th century and up until his death in 2001. There is therefore not only a lingering effect from his Steady State theory, but also from Hoyle's rejection, of both the Big Bang and biological evolution. Hoyle was not alone in the second half of the 20th century in casting doubt on both the Big Bang theory and biological evolution, as is shown by Toulmin and Goodfield (1967,) who gave equal rating to the Steady State theory and gave detailed objections to biological evolution in their popular science writings of the period. The New Scientist provided a review of Hoyle (1983), that rejected both the Big Bang and biological evolution in favour of the Steady State and Panspermia, stating it had a "lavish presentation, the inimitable style …… make for a riveting read" (Hoyle, 1985, p. ii), illustrating the popularity of his writings among some in the scientific community. As well as being uncomfortable with the full implications of the Big Bang and biological evolution, it is important to remember that Hoyle also enjoyed encouraging opening minds to possibilities, that many scientists would reject, confirmed in his 1992 address to the International Symposium on Observational Cosmology in Italy, "The need in cosmology is to open doors, not to close them" (Hoyle's address to the conference, in Mitton, 2005, p. 341). In retrospect it is perhaps easy to criticize Hoyle as a major contributor in rejecting in whole or in part either theory, but Sagan defends him:

> Sometimes he's succeeded by being right ……. Sometimes he's succeeded by being wrong – by being so provocative, by suggesting such outrageous alternatives……. The impassioned and concerted effort to "prove Fred wrong" has sometimes failed and sometimes succeeded. In almost every case, it has pushed forward the frontiers of knowledge. (1997, p. 256)

2.7.1 Confirmation bias and motivated reasoning

A further possible relevant behaviour among those that reject the Big Bang theory and theory of biological evolution is noted in "confirmation bias" or "motivated reasoning" where an intelligent individual seeks to find only evidence that supports the individual's

faith or belief. In addition, confirmation bias can also lead to, or provide a feeling of happiness, as the belief it reinforces is one that makes the individual happy or content. Otto, (2016), provides Ben Carson as an example of this theory; a retired neurosurgeon, U.S. Presidential candidate and Seventh Day Adventist. In accordance with his faith he dismisses both the Big Bang and biological evolution, despite being fully aware of the considerable scientific evidence for both theories and instead take a fundamentalist Biblical standpoint because of his religion; "Darwin came up with something that was encouraged by the Adversary [the devil]", and of the Big Bang "I mean, you want to talk about fairy tales [the Big Bang], that is amazing" (Carson cited by Otto, 2016, p. 210). The observations of Mitton (2005) may suggest that Hoyle, and his closest two professional friends, were examples of both avoidance of cognitive dissonance and confirmation bias:

> A triangular affair involving Fred Hoyle, Geoffrey Burbidge and Jayant Narlikar ……. The trio worked on what had become for them familiar topics …… The three convinced themselves ……. However, their arguments [against the cold death of the universe] failed to win any support outside their own small group. (p. 339)

An "anti-science bias" was noted within a minority of the population of the United States by Fauci, that he did not blame on religion, but instead commented:

> One of the problems we face in the United States is that unfortunately there is a combination of an anti-science bias that people are, for reasons that sometimes are inconceivable and not understandable, they just don't believe science and they don't believe authority ……. It's amazing sometimes the denial there is. (2020)

2.7.2 The sleeper effect

As well as searching for any evidence of avoidance of cognitive dissonance and confirmation bias this study will also look for any evidence of the "sleeper effect" where newly formed opinions may appear with the passage of time to gravitate back to the opinion or belief held prior to receiving new information or evidence (Hogg and Vaughan, 2013, p. 202), or where a low credibility source of information becomes more persuasive or regains persuasiveness days or weeks later (Colman, 2009). Over time a credible source giving evidence based information and a less credible source giving information without evidence can become as

persuasive as each other, as “the message survives but the source does not” (Hogg and Vaughan, 2013, p.203), thereby in some instances individuals may be given scientific facts that are believed at the point of transmission, but are later rejected in favour of an alternative belief, that may have been previously held, despite there being evidence for the former and no evidence for the later, as over time the sources and their credibility are forgotten but the non-scientific belief, message or viewpoint remains. Theoretical examples of the “sleeper effect” would be an individual acknowledging the validity of evidence concerning biological evolution or the Big Bang, but then days later reverting back to a former belief in Biblical creation , or the Panspermia theory, or the Steady State theory.

2.7.3 Intuition

A feeling of intuition may also impact on acceptance or rejection. Intuition is defined as apparent knowledge and understanding without evidence or reasoning (Colman, 2009). An intuitive/counter-intuitive view may follow from an already existing belief in acceptance or rejection. Mosley and Lynch (2010) propose that ideas can be simple, intuitive and wrong, giving the example in classical Greece that the earth was at the centre of the universe with the sun going around it. This example, by Mosley and Lynch, also illustrates that commonly thought intuitive ideas change over time and in different ages and settings, as intuition is not a reliable guide to truth, but can be context and time period dependant.

2.8 Summary of literature review

The literature review has suggested a model of opinion formation that recognises the influence of deep and broader factors in the rejection or acceptance of scientific theories by individuals, which is similar to that proposed by Vygotsky (1978). The literature review suggests thematic explanations for the rejection of the Big Bang theory and the theory of biological evolution; the effects of religious belief on science learners, differences in teaching methods, failings in science communication methodologies and academic disputes, the lingering effect of discredited theories and psychological reasons, including cognitive dissonance, confirmation bias and the sleeper effect.

However, Singh (2004) suggests rejection of either theory is strange, as both scientific theories of the Big Bang and biological evolution are easily understood and are not counter intuitive:

> The Big Bang model offers an elegant explanation of the origins of everything ……. Even more wonderful is that the Big Bang model can be understood by everyone ……. Just as Chares Darwin's theory of natural selection is both fundamental and comprehensive to most ……. the Big Bang model can be explained in terms that will make sense to non-specialists. (pp. 3-4).

Hoyle (1983) admitted that "I suspect that one of the reasons that the Big Bang theory has proven so popular is that it is an idea which, at the simplest level, is easy to grasp" (p.171). Not only are both theories of biological evolution and the Big Bang easily explained, easily understood and possibly intuitive to a non-specialist audience, neither theory requires the use of an equation in its explanation. Stephen Hawkins was informed that adding one equation to a book halves the readership among a general audience (Crease, 2009, p. 157), and later commented:

> Most people cannot follow mathematical equations. I don't care much for equations myself. This is partly because it is difficult for me to write them down, but mainly because I don't have an intuitive feeling for equations. Instead, I think in pictorial terms, and my aim in the book [*A Brief History of Time*] was to describe these images in words. (Hawking, 2013, p. 95).

Yet despite containing no equations, some individuals do not accept either or both theories, either in whole or in part. The aim of this thesis is to study, examine and explain the factors that may be at work influencing learners to accept or reject the theories. While some academics have attempted to firmly blame religion for the rejection of both the Big Bang and biological evolution, (for example, Dawkins 2006 and 2008, Skehan et al 2000, Moore et al 2011 and Moore and Cotner 2013), religion does not explain the occurrence of rejection among non-religious individuals or atheists. Hoyle did not believe in an Abrahamic omnipotent God, as in his view "religions with an all-powerful God make no sense" (1994, p. 421). He was also scientifically literate, lecturer in mathematics at Cambridge, Professor of Astronomy and Experimental Philosophy, and Director of the Institute for Theoretical

Astronomy. Yet this non-religious and very intelligent, scientifically literate individual rejected both the Big Bang theory and biological evolution to his death in 2001 (Singh, 2004). This thesis will examine if today, others think the same as Hoyle, and if so, why.

The conceptual framework suggests that an individual's views of scientific theories are formed over time as part of a process (Turner and Oakes 1986, and Tajfel 1982). Existing theories of belief formation from early childhood are a starting point to understanding the formation of more developed and detailed opinions. Belief formation is not a "one off" decision and is instead complex, multi-faceted and multi-layered, where the process of meaning-making to form perspectives and belief formation is a lifelong activity (Kegan, 1982). The process of belief formation can continue until death, taking shape from all aspects and all ages of life, resulting in a developmental process of stages in belief (Fowler, 1995). Belief is subjective not objective (Kim 2022). Changing belief via revision can be difficult because of several factors, including any stress that an alternative view causes, conscious or unconscious bias, or irrational belief, perhaps due to mental illness (Glover 2014). Individuals can often use a mixture of rational logic and life experiences, including influences from educational and religion. In 1927 Russell suggested, but did not investigate via research, that belief in God, the Biblical creation of the universe and life within in it, was often not the result of intellectual argument, but because the individual was taught it from infancy, (1957). This suggestion signposts and informs an examination of the life history of individuals from infancy, to gain evidence of the influences that resulted in rejection of the scientific theories of the Big Bang and biological evolution.

More recent theories of opinion formation suggest an individual's opinion formation can result from a progressive evolution of a view (Chacoma and Zanette, 2015) where misleading sources can influence the opinion (Medo, Mariani and Linyuan, 2021), and where opinion formation can play a prominent role in societies, including polarizing opinions in society concerning science theories, for example covid-19 and measures taken to stop its spread (Chan, Duivenvoorden, Flache and Mandjes, 2024). The following methodology, detailed in Chapter 3, was used to investigate if some or all of the explanations given in the literature review influence the rejection or acceptance of the two scientific theories, and if participants indicated any additional factors.

Chapter 3: Methodology

3.1 Introduction

This chapter will examine the research paradigm, ontology, epistemology and chosen methodology for the research. The choice of methodology was informed by the theories of belief formation of Turner and Oakes (1986), Tajfel (1982), Kegan (1982), Fowler (1995), Glover (2014) and Kim (2022), the theories of opinion formation of Chacoma and Zanette (2015), Medo, Mariani and Linyuan, (2021), and Chan, Duivenvoorden, Flache and Mandjes (2024), together with the conceptual framework of possible influences. The case will be put forward to justify the chosen methodology, paradigm and approach that were selected to address the research questions. The participant selection, data collection and analysis will be explained, and the quality criteria and ethical considerations will be discussed.

Mertens (2015) confirms that research is conducted for a variety of reasons, including to understand, describe, predict, or control a phenomenon and unlike other ways of knowing, such as insight and acceptance of authoritative dictates, it is a process of systematic enquiry that is designed to collect, analyse, interpret and use data. This study will be framed using Mertens' description of systematic enquiry so that the resulting data can be used to address the issue of rejection of two scientific theories, which may have a detrimental impact of reducing learning pathways, subsequent employment and further study options (Dawkins, 2008).

3.2 Paradigm, ontology and epistemology

A paradigm frames the educational research of this study and determines the chosen positions of the thesis regarding ontology, epistemology and methodology. Having considered the debates of opposing paradigms and positions and taking the research questions as a tool to refine the paradigm choice (Andrews, 2003), this study follows an interpretivist paradigm.

Paradigm

The term paradigm derives from the work of Kuhn (1962) to explain the development of new ideas and ways of seeing the world in science, which results in a new shared understanding (Coe, 2012)**.** Research paradigms can be defined as views on the best ways to think about and study the social world and involve systems of beliefs and practices that draw on theoretical assumptions and justifications (Punch, 2005 and Cohen et al, 2011). Four research paradigm positions have been considered for this study: positivism, interpretivism, constructivism and critical research, each having its own distinct ontology, epistemology and methodology (Cohen et al, 2011).

The positivist paradigm analyses and interprets subject matter using methodologies drawn from, or similar to, the natural sciences that may provide the clearest knowledge and that can be applied to social research. The main assumption of this position is that the researcher has a role of "the outsider looking in", aiming to discover causal relationships, using scientific, naturally occurring, empirical quantitative data (Gage, 2007). By contrast, other paradigms challenge the positivist assumption that objective truth about the world makes itself so readily available to us. The constructivist paradigm suggests the human social world is continually built and rebuilt with no single interpretation, as any single understanding is a construction out of many that are possible, although collective meaning-making can be achieved due to shared communication of meanings and knowledge (Cohen et al, 2010). The critical research paradigm aims to uncover relationships that can result in inequality so that people whose needs are not being met can be identified and helped to over-turn the status quo. This paradigm is a form of ideologically oriented enquiry (Gage, 2007). The interpretivist paradigm would suggest that individuals and groups are a product of their environment, where they are shaped by experiences and underlying influences (Cohen et al, 2010). Interpretivist research investigates participant's experience, views and perspectives and is therefore the most suitable for this study.

There are several areas of contrast and overlap when one examines the paradigm positions in detail. Within positivism, natural science is the model for enquiry, aiming to uncover causal relationships using quantitative empirical evidence to discover general laws. Positivism contrasts with the critical research paradigm that challenges ideology and power

with an emancipatory aim based on critical social science (Cohen, et al, 2010). Constructivism also rejects assumptions and prevailing viewpoints in a radical way that offers frameworks in a participatory way, for example in professional practice (Gage, 2007). These contrast with critical theory that can align with oppressed groups (Cohen, et al, 2010). Interpretivism aims to explain patterns in a qualitative way where the aim of the researcher is one of the insider 'looking out' at influences, as opposed to the positivist outsider 'looking in' (Gage, 2007) and is therefore more suitable. The paradigm choice can further be justified as its elements fit with the specific aims of the study as suggested by Guba's justification of paradigm choice (1990). The study probes value-laden concepts including perceptions, beliefs, relationships, attitudes and opinions, thereby requiring the oblique and exploratory approach characteristic of naturalistic paradigm methodological axioms (Lincoln and Guba, 1985 and Cohen, et al, 2010).

Ontology

This study follows an interpretivist ontology. Ontology can be defined as one's view of reality, taking into account any assumptions about how we understand the social world, how we understand learners, what should be studied to support learning and whether learning is an individual or social activity (Waring, 2013). The ontology underlying each position varies considerably. Positivist ontology suggests reality is independent of the researcher and that reality often consists of pre-existing patterns that are stable. Reality can therefore be measured and is predictable in terms of cause and effect. Therefore, statistical relationships can be found in human behaviour, to the extent that patterns can be generalised (Cohen, et al, 2011). The ontology of critical theory suggests although external reality exists, it can be affected by social and political systems. Therefore, the purpose of the researcher's work is to uncover relationships that involve inequality and empower the oppressed in a struggle for improvements (Gage, 2007). Constructivist ontology draws on similar assumptions to critical theory, but suggests reality is built and formulated, and cannot always be universally known as fact, as there are many competing interpretations of the same phenomena effectively producing multiple realities, as individuals make sense of the world based on many things, including experience (Cohen, et al 2010). The constructivist ontology suggests human behaviour is context dependent and that reality is subjective (Gage, 2007). The interpretivist ontology is connected to the research of studying the life

paths of individuals by exploring their subjective lived experiences (Cohen, et al 2010, Waring 2013), that can be linked to the two scientific theories and is therefore most suited. The proposed interpretivist approach is connected to the research examination of the perceived subjective experiences of the respondents, uncovering meaning through dynamic interactive dialogue between respondent and researcher.

Epistemology

This study follows an interpretivist epistemology. Epistemology can be defined as how we know what we know about the world, and concerns theories of knowledge which attempt to explain what knowledge is and addresses the question of whether some forms of knowledge are more productive than others (Waring, 2013). Other epistemologies were considered unsuitable. Positivist epistemology suggests that knowledge can be described in a systematic way as it is certain and accurate. Theories can be tested and proven. Therefore, knowledge consists of proven hypotheses providing facts or laws that are probabilistic, occurring in different contexts and holding true for large groups. Phenomena and findings can therefore be observed, measured, predicted, controlled and replicated (Gage, 2007). Constructivism is opposed to positivism because, to the constructivist researcher, the concepts of science are in fact mental constructs used to explain sensory experiences. Constructivist epistemology suggests knowledge is built and formulated from individual and communal experience, thereby rejecting the positivist view of the universal validity of knowledge (Cohen, et al, 2010). Critical research epistemology has a subjective approach to knowledge but with the aim of educating the research participants and to instigate and integrate research and practice, encouraging self-reflection and inspiring participants to make changes (Gage, 2007). Interpretivist epistemology, which is most suited to this study, suggests individuals have subjective interpretations of events and each will often respond differently to the same situation because of their own subjective knowledge founded on their own individual understandings, beliefs, attitudes and opinions (Cohen, et al, 2010).

Options of methodology

As interpretivism suggests learning is an active process of building and formulating knowledge, where individuals negotiate and do not simply receive meaning, and where learners are agents of their own learning, being selective and proactive (Cohen, et al, 2010),

an interpretivist epistemology links well to the life history methodology. This examines the individual's building and formulating of factors that influence their acceptance or rejection of the scientific theories throughout their lives.

Methodology can be defined as an approach to enquiry that specifies how research questions should be asked during the research and subsequently answered by subjects (Waring 2013). Research methods involve the tools and techniques used by researchers to produce information and data on the research topic in question, for example by using among other things interviews, surveys and observations. These can be undertaken using either quantitative, qualitative or mixed methods, depending upon their suitability and the requirements of the research topic, the researcher and the subject and the people being researched (Punch, 2005).

Some of the methodology and methods of each of the paradigms are unsuitable for this research thesis. For example, positivist methodology makes use of scientific methods that aim to produce objective data on a quantitative basis to test theories and guide practice. Methods might include surveys, questionnaire, observations undertaken in a systematic way and experiments, including random controlled trials (Cohen, et al, 2011). Positivist methodology is not suitable to this research thesis as quantitative statistical data cannot examine factors and influences that effect individual's perceived reality. Interpretivist methodology involves investigating the participant's experience and perspectives. The methodology needs to be exploratory with no prior value-laden positions. Interpretivist methods might include qualitative interviews, observations and field notes seeking to gain understanding (Gage, 2007). Each paradigm requires different tools and procedures, producing different types of research data. The positivist requirement of control of variables, seeking experimental external validity would not be suitable as it contrasts with the investigation of discourses, language and documents of interpretivism (Cohen, et al, 2010 and Cohen, et al, 2011).

The chosen interpretivist approach also enables use of post- and late-modern and re-emerged methodologies, the later having regained respect in social studies, for example the life history approach (Goodson and Sykes, 2010). The use of the life history approach enabled the study to examine the rejection or acceptance of the two scientific theories, that

may not exclusively be the result of rational propositional logic but may instead be enmeshed within the context of their life experiences, including religious and political influences, as well as the teaching methods the individual experienced at schools and colleges.

3.3 The life history approach

A life history approach to data collection was chosen because of its clear fit with the chosen paradigm and an interpretivist methodology. No other approach provided the methodology that was necessary to systematically study the factors from early childhood to late retirement that influence the acceptance or rejection of the Big Bang theory and biological evolution among life-long learners, in a chronological data collection process. The life history approach is a unique methodology that catches a chronology of events to infer causality (Cohen et al, 2011). Further, the life history approach removes the assumption of what is 'known' and enables examination of other people's subjective perceptions, without the need to judge the factual basis of various beliefs (Goodson and Sykes, 2010). Relevant to this study, the life history approach systematically examines an individual's thoughts and helps in the understanding of both the individual, and the groups that individuals may belong to (Baker, 2009). Yow (2005) confirms that this approach enables the study of "the inner struggles and motivation, [and] the way psychological makeup influenced the subject" (p. 220). This approach can be defined as a data capture method that stresses the entire biography and background of the subject, linking the past with the present, due to the links of the chain of social transmission (Goodson and Sykes, 2010), thereby providing data that can establish the factors that influence the acceptance or rejection of the Big Bang theory and biological evolution in lifelong learning. In this way the study can free the voices of participants that have been "acted upon" by influences at various points in their lives.

The life history approach, in the view of Tedder (2012), offers not only the possibility to learn from participants' lives but it also has potential to consequently effect change. Cohen et al (2011) also confirms the suitability of life-history studies as they are evidence-based, catching the chronology of events as they unfold over time to enable the researcher and the study's aims. The evidence-based nature of life history research is also confirmed by Patton,

who further comments that it is “entirely a first-person narrative, with the researcher removed as much as possible from the text” (2015, p.434). In order to maintain the evidence-based nature of the research the data obtained from the life history method must be kept in context, otherwise some elements of data can be deprived of their intended meaning (Punch, 2005). This can result in extended quotations being used to confirm and retain context. If suitably undertaken, life history research can “provide insights into individual experiences of change, whether the change is personal, psychological and educational, or social, political and cultural. No other form of research focuses so explicitly” (Tedder, 2012, p. 327). Of the several types of textual data collected using different methods, Baker (2009) confirms the life history approach provides a significant increase in the detail of evidence obtained. The life history approach has experienced a re-emergence and renaissance in educational research exploring viewpoints and beliefs in lives. Tedder confirms that there has been an historical “ebb and flow of biographical methods” (2012, p.323). Baker (2009) suggests that after the pioneering work of the Chicago School of Sociology in the first half of the twentieth century there followed a pendulum reaction against life history research and then back to popularity in the second half of the twentieth century, that has in the early twenty first century equalised and resulted in balanced views of biographical and life history methods, including Chamberlayne, Bornat and Wengraf (2000) and Rustin (2000), that both describe life history research’s “biographical turn” in social science research (Chamberlayne et al, 2000, p. 1 and Rustin, 2000, p. 33). Baker (2009) confirms life history and narratives have emerged as a major force in social science research.

3.4 The participants

To select participants the researcher used purposive sampling, recommended by Bryman (2008), to establish a correspondence between research question and sampling so that individuals who are relevant to the research question were interviewed. Mertens (2005) confirms that within the paradigm of this study purposive sampling enables the researcher to select samples with the goal of identifying information-rich cases, while still achieving a variety and contrast of dimensions, including age (18 – retired), gender, religion, educational

background and occupation, that would ensure the participants were representative of the population of the United Kingdom, as far as was possible, thus avoiding sampling bias.

Goodson and Sykes (2010) view the number of participants required should be based "not upon quantity but upon the richness of the data", (p.23). Morse (1994), Creswell (2007) and Mertens (2005) recommend total respondents of 5 or more in order to understand phenomena. Mertens, within this range, specifically recommends 6 to 10 participants to obtain significant results (2015). Jolly (2016) utilised 10 participants. Strauss and Corbin (1998) suggest 10 participants for grounded theory research, which is also in the range recommended by Saldana (2021). Based on these six recommendations the researcher selected 10 purposive sampling individuals for the study, undertaking a total of 20 interviews, being 2 interviews per individual.

Baker (2009) confirms multiple life history stories can reveal shared themes. The individuals selected had attended lifelong learning courses, lifelong learning discussion groups or work-based courses within the last five years and each confirmed they will be undertaking further lifelong learning courses, which may include science. Participants of the study were as far as possible representative of the population. The study contained 5 male and 5 female participants giving a suitable study representation based upon approximate male/female equal representation with the country (Birth Ratio of Great Britain, 2011/2015). The participants were split 6 employed/self-employed, 1 job seeker and 3 retired, in approximate accordance with 75.7% employment rate, 4.8% unemployment rate and 19.5% retired (Office for National Statistics, 2017). 7 participants were aged 18-65 and 3 participants over 65, in accordance with 80% of total population below 65 and 20% of total population over 65 (Office for National Statistics, 2017). 5-degree level participants and 5 non-degree level, representative of 49% of education participation in higher education in England (Office for National Statistics, 2017). 5 Christian, 1 Muslim, 1 Hindu, 1 Buddhist, 2 no religion/religion not stated, representing 50% Christian, 7% Muslim, Hindu 3rd largest at 3.6%, Buddhist 4th largest at 1.2%, 37% no religion/religion not stated (Reading Census, 2011). In order to understand the influences for both rejection and acceptance, 50% of the participants rejected one or both theories, in whole or in part, and 50% accepted both theories. The overview of study participants is provided in table 3:

Table 3. Overview of study participants

Participant pseudonym	Biological Evolution: Accept/ Reject/Other	Big Bang: Accept/ Reject/Other	Age	Gender. Self-identified as:	Ethnicity. Self-identified as:	Work/ Retired
Barbara	Other. Rejected parts of theory	Accept	45	Female	White British	Teaching assistant
Howard	Other. Rejected parts of theory	Rejects	83	Male	White British	Retired teacher
Peter	Accepts	Accepts	53	Male	White British	Charity executive
Dean	Other. Rejected parts of theory	Other. Rejected parts of theory	43	Male	Arabic	Telecom company
Jill	Accepts	Accepts	69	Female	White British	Retired from various jobs
Ella	Accepts	Accepts	19	Female	White British	Shop assistant
Josh	Accepts	Accepts	18	Male	Indian British	Job seeker
Sue	Accepts	Accepts	31	Female	White British	Retail
Ann	Rejects	Rejects	72	Female	White British	Retired from office administration
Roger	Rejects	Rejects	52	Male	White British	Gas engineer

Participant pseudonym	Religion	Politics	Type of science education received at school	Highest qualification/ Education level	Most recent lifelong learning course taken
Barbara	None. Atheist	Not aligned	Universal	Degree	Teaching Assistant course.
Howard	Christian. Church of England.	Conservative	Universal	Degree	Church management course.
Peter	Christian. Baptist.	Liberal Democrat	Universal	Degree	Church outreach course.
Dean	Muslim. (Sunni).	Not aligned	Multicultural	Degree	Information Technology course.
Jill	Christian, Methodist and C of E	Not aligned	Universal	Degree	Church leader mentor course.
Ella	Christian, Roman Catholic	Not aligned	Multicultural	A Levels	Customer services course.
Josh	Hindu	Not aligned	Universal	A Levels	Job Seeker course.
Sue	Buddhist	Labour	Universal	A Levels	Retail course.
Ann	None.	Conservative	Universal	A Levels	Various courses.
Roger	Evangelical Christian	Conservative	Universal	City and Guilds, HND	CPD Gas Safety course.

The selection of the participants was undertaken in three phases. The first phase involved selecting those individuals that provided the required diversity for the study. To do this the researcher visited community centres, colleges and places of worship and engaging in discussion with potential participants. The second phase involved those having been identified being given the precise nature and requirements of the study, via the Information Sheet, approved by the University, given in Appendix 1. The third phase involved the participants agreeing to the process and being given the ethics committee approved Consent Form, to confirm their agreement to take part, given in Appendix 2.

3.5 Data collection procedures

The life history approach can use structured, semi-structured or unstructured interviews, as there is no "lockstep approach" (Mertens, 2015, p. 261). For this study a semi-structured format of interviews was devised using a mixture of prompting open and closed questions, recommended by Baker (2009). The questions centred around the main issue of the study to reveal insight into the factors that influence the acceptance or rejection of the Big Bang theory and theory of biological evolution among lifelong learners. Mertens points out the need not just to ask, "very open-ended probes, such as *Tell me about ……*", but to "use a more direct approach, inquiring specifically about areas that might not be brought up otherwise" (2015, p. 298). This process requires a balance between professional posture and nurturing an atmosphere that promotes authentic communication (Chirban, 1996).

The interview prompting questions were formulated from the research questions, literature review and chosen methodology. The interview construction allowed flexibility of verbal interaction to "meander according to the respondents' responses" (Minichiello, 1990, p.116), so that findings could emerge. Open style questioning gave latitude for the respondents to raise themes they felt important (Baker, 2009), resulting in interviewer-interviewee collaboration. The interviews were undertaken within a convivial and empathetic atmosphere (Chirban, 1996), where it was important to show respect and sensitivity towards the respondents' role as co-constructors of raw personal data (Seidman, 2006).

Integral to the study is the researcher's role as co-meaning maker and interpreter, recognising reflexivity, as although the researcher may not always know in depth what a participant means, the researcher must make the most sensitive interpretation from the basis of the researcher's own world view. The interview process ensures that respondents' meaning-making can emerge from cultural-historical processes, as learning can be culturally mediated (Vygotsky, 1978), although the study recognises that Seidman proposes "there is no solid, unmovable platform on which to base our understanding of human affairs" (2006, p.26). Yow (2005) suggests starting the interview process with general questions and Seidman (2006) recommends that a life history study should not consist of just one long interview.

By using two interviews, any interview fatigue was minimised and being carefully split, certain data collected from each sub-interview, for example dates, periods and views were checked for accuracy between the two. A two-stage interview procedure was therefore devised, (the schedules of which are given in Appendix 3), consisting of a stage one short interview that would last between thirty minutes and one hour, that would provide the participant with an introduction to the study background and aims, and detail the participant prerogatives and rights, before asking for key background information areas of the participant, that may be found to be relevant to the study of the research question. This information would also confirm the representative nature of the participant. The first interview went on to confirm the current views of the participant concerning the two scientific theories that are the subject of the study.

As part of the interview process the researcher provided "orientations and considerations" (Baker, 2009, p. 10), and as part of this first short interview an essential element of the research was to undertake to check the level of understanding of the terms to be used in the research: "Big Bang", and "biological evolution". Each individual was asked to confirm their understanding of the terms "Big Bang" and "biological evolution", subsequently compared to a simplification of the definition given by Nussbaumer and Bieri (2010) and May et al (2012). These define the Big Bang theory as a model constructed that fits available evidence from the Universe, that suggest all matter and energy originated from a state of intense density and temperature, that expanded at a moment in the past that is finite, and resulted in the commencement of space-time, fundamental forces, matter and energy, that

then inflated and continues to expand today, so that the original process and directions are still in progress. An example of simplification would define the term as “the commencement or start of the Universe from a small point that inflated and that continues to expand today”. Biological evolution is defined by Daintith and Martin (2010) as the process by which all life on earth arose from the earliest primitive organisms and last universal common ancestor, which existed over three thousand million years ago, giving rise to biodiversity, where there has been change in heritable characteristics over successive generations. The simplification might define the term as “the process by which current life on earth has changed or evolved over generations into different species”. If the terms were not generally understood this might indicate a lower-than-expected level of scientific literacy. The first interview ended by confirming the current views, (not historical view at this stage), of the participant concerning the two scientific theories, which are the subject of the study. A break followed, with refreshments and sustenance, before the commencement of the second interview.

The second longer interview was designed to establish the life history experiences that have influence the participant’s acceptance or rejection of the Big Bang theory and the theory of biological evolution. The interview was designed to be longer than the first, although the time taken depended on the age and level of life experiences of the respondent. A maximum time limit of two hours was set for ethical grounds, on the basis that a longer interview might be uncomfortable both mentally and physically, reconvening, if necessary, after a further break. All second interviews were completed within the two-hour period. Areas of life history were explored during the interviews that included: parents/family background, preschool years, primary school, secondary school, adulthood. Within these periods, themed open and closed questions prompted discussion. The second interview also asked questions to ascertain if the interviewee has any feelings about the theories, including their implications and consequences if true, to ascertain any levels of avoidance of cognitive dissonance. The two stage Interview Schedules, (given in Appendix 3), were designed to investigate if there are different and multiple reasons for the rejection or acceptance of either the Big Bang theory or the theory of biological evolution and noted an individual may accept the Big Bang but not accept biological evolution, and vice versa, with differing reasons/influences from their life history that may explain this phenomenon. In addition,

the interviews investigated if there were differing reasons between age groups for the occurrences of non-acceptance.

3.6 Research tools

The research tools that enabled the study consisted of the interviews, the interview venues, the raw data collection devices, and the qualitative data software. The twenty interviews took place in accordance with the agreed venues given in the study ethics committee approval documents. In accordance with the risk assessment, made in 2018, all the venues fell within the Health and Safety responsibilities of either the community centre, religious building or the university and were suitable for the study to take place. Subsequently any handwritten interviews notes, typed notes or recordings were transcribed.

The researcher did not use an auto code option data analysis programme and instead coded manually. Following the researcher's own review of using three data collection and analysis tools, (ATLAS, Microsoft Office 365 and NVivo), the researcher chose to manually code using Microsoft Office 365 based on its full compatibility of all documents, as well as the researcher's personal preference of word processing software for the study based on personal usability, that is an essential consideration (Punch 2005 and Saldana 2021), especially for researchers that are neurologically atypical.

The computer software word processing package Microsoft Office 365 can support qualitative research methods by helping store and organize raw data from interviews (Walker, 2023). Microsoft Office 365 conforms to the five factors listed by Punch for consideration when selecting a software package: compatibility with the researcher's analytic approach, ease of use, product support and upgrade path, a supportive learning community and the cost of the software (2005).

3.7 Data analysis

Baker confirms the life history approach "generates theory from transcribed texts" (2009, p. 4). Data obtained from the transcribed texts was organised within Microsoft Office 365

Word files for accessibility. Data was analysed and interpreted using procedures suitable for life history approaches (Goodson and Sykes 2010, Saldana 2011 and 2021). Within the thesis findings chapters the participants' actual words, phrases and sentences are used and given within their context as evidence (Baker, 2009).

The twenty interview transcripts that resulted from the life history methodology provided significant amounts of raw data. Baker (2009) confirms life history transcripts can be stored and coded, with connections made between codes that can then be re-sorted and reassigned if necessary, during ongoing or subsequent final coding when new codes may surface. It was important therefore in this study to prepare for the possibility that new themes and codes might become apparent at any stage up to and beyond the coding of the last interview, as each step of the coding process may result in significant new findings (Gibbs, 2012).

It is essential to work systematically in coding raw data (Saldana, 2011, 2021, and Kara, 2023). Within the qualitative analysis of this thesis a code symbolically assigns a summative and essence-capturing attribute for portions of language-based date from interview transcripts (Saldana, 2021). The first cycle of coding is taking apart by analysis and the second cycle is synthesis by putting together into new assemblages that have meaning (Saldana and Osmasta, 2018), that is required for theory building (Vogt et al, 2014). However, if a code is applied during the first cycle or second cycle it is not fixed but is instead malleable, as heuristic fluidity is essential during coding (Locke et al, 2015). The first and second cycle "codes-to-theory model for qualitative inquiry" of Saldana (2021, p. 18), is the model used in this thesis whereby significant amounts of data are placed into a number of codes and themes, resulting in assertions and final theory. This model runs from the real and particular to the abstract and general, via first cycle and second cycle coding, including analytical memoing, where during this process codes and themes were created to assist the qualitative inquiry (Saldana 2011 and 2021). Just as transcribed data can be placed into multiple codes when relevant, so too codes can be placed in more than one theme if justified during the coding process (Harding, 2019). Recoding can also occur during the process, especially in subsequent cycles of coding to maximise analysis of data (Saldana 2021).

Some initial codes were devised a-priori, for example teaching methods encountered at school, religious influences and the individual's scientific literacy, which were clearly indicated as potential codes based on the literature review. Other codes emerged during coding and thematic analysis, for example changes in viewpoints during lifetime and differences in interpretation of evidence. This mix of deductive and inductive coding confirms that a researcher may start with some codes, based upon the literature review, and the researcher is also open to new discoveries, and therefore new codes that emerge (Miles et al, 2020 and Saldana 2021). Cumulative coding cycles ultimately lead to the development of a theory grounded and rooted in the original data, that helps explain the rejection or acceptance of both scientific theories. During the coding cycles the twenty transcripts were subjected to first cycle and second cycle methods recommended by Saldana (2011 and 2021): Holistic Provisional Coding, and In Vivo Coding. The coding method resulted in significant levels of findings, given in the findings chapters. An example of coding is given in Appendix 5.

3.8 Trustworthiness, reliability and validity

After each of the twenty interviews ended the *Post Interview Establishment of Reliability and Validity* checklist, given in Appendix 4, was completed by the interviewer with the interviewee to establish any potential areas of bias, questionable reliability or validity. This checklist was based upon the potential areas identified by Tedder 2012, (p.327), and those areas tabulated by Plummer 1983, (p.103), and areas of an adaptation of Plummer 1983 by Cohen et al 2011, (p.214). Mertens recommends "recognizing the faults of human memory, researchers should be concerned with two aspects of the data: consistency in the testimony (reliability) and accuracy in relating factual information (validity)", (2015, p. 297). The use of the checklist confirmed the studies reliability and validity. The completed checklists also noted that each interviewee was representative of the population and assisted the study in being representative as far as possible.

The post interview checks also confirmed that each interview was conducted in accordance with the ethical requirements of the University of Reading. No bias was noted, and no questionable validity or reliability was noted. It was noted that all interaction was suitable

before, during and after the interviews. All participants provided reliable data with only minor, mainly childhood areas that could not be recalled. The researcher's demeanour and personality were suitable, with no complaints made by the participants, and no expectation of answers was made during the interview.

During coding correlations can occur that do not always imply causation, and spurious correlations can occur where a seeming relationship is not actually the case (Cohen et al, 2011 and Gorard, 2012). Neuman (1994) argues that attempting to find causation is pointless because life, individuals and society are too complex and continuously changing. However, Hammersley and Atkinson (1995) and Miles and Huberman (1994), argue that causation is important to qualitative research. In searching for causation "we get inside the black box; we can understand not just that a particular thing happened, but how and why it happened" (Miles and Huberman, 1994, p.434). Further, different and multiple causes and variables "are not disembodied but have connections over time" (Miles and Huberman, 1994, p.147), that can be discovered by the life history method, giving it a distinct advantage over other research methods.

Punch (2005) argues that the terms "cause" and "effect" should be replaced by other terms because cause is an "interpretation [that] is an inference" (p. 51). Punch (2005) points out potential difficulties in that to say X causes Y is to say that every time X occurs, Y occurs due to a constant conjunction, and that a view of necessary connection where X causes Y is to say X is followed by Y and that X must be followed by Y. Night always follows day, however the researcher cannot say that day causes night. An example found during coding of this study was that rejection appeared to be linked to political party voting history, however none of the political parties in the United Kingdom had ever mentioned either scientific theory in their manifestoes (Clark, 2018). Therefore, constant conjunction alone does not seem to be enough to define causation. The researcher cannot observe that X must be followed by Y. It can only be observed whether or not X is followed by Y. We cannot observe the necessary part. Since it cannot be observed, it must be inferred. Punch therefore argues that the term "cause" should not be used and should be replaced by "variables" (p.50), and by using the definitions of Arthur et al (2012) and Cohen et al (2011), the causation factors are the independent variables, the rejection or acceptance of the science theories is the dependent variable and any factor that influences both the dependent variable and the

independent variable(s) causing a spurious association or link is a confounding variable. The term “cause” is not therefore used in this thesis, and instead the term “factors that influence” is more appropriate.

3.9 Ethical considerations

The ethical issues arising from the research were ones of informed consent, confidentiality, recording data, use of participant data, quoting extracts and participant emotions. These ethical issues were firstly addressed by ensuring that informed consent was obtained before each interview. Confidentiality and quoting extracts were addressed by protective pseudonyms and anonymising place names, teachers, family members and groups. Anonymisation is an essential tool that enables the researcher to share data while preserving privacy (Cohen et al, 2011). Interview time durations were set, and meeting locations and times were agreed in advance. It was possible for the researcher to take notes, type, or record answers depending on the preference of the interviewee. The twenty interviews took place at local community centres, the participant’s home, religious building or in the meeting rooms of the University of Reading, depending on the preference given by the participant. The 20 interview notes, typed answers or recordings were subsequently transcribed to the word processing package Microsoft Office 365 prior to coding. All interview data is held securely by Research Data Service, University of Reading (Blagrove, 2023).

Participant emotions during life history interviews may well at times be ones of happiness or sadness in recalling life events and this was anticipated by the researcher following the study of relevant articles (Chirban 1996 and Seidman 2006). Emotions do not detract from authenticity, but instead emphasise the power of the life history approach being used. This study recognises the caution raised by Goodson and Sykes (2010) that “engaging in life history work can sometimes be painful in that informants may find themselves revisiting distressing events .... although effects cannot be easily predicted, the fact remains that being in life history work can alter lives” (p. 109) and the interviewer was mindful of this, and could use previous training with Social Services, concerning interview emotions, if required. The potential for emotion to surface during the research is also confirmed by

Tedlock (2017) who comments there will be “a narrative arc with a beginning, middle, and end, as well as high and low points of dramatic development including moments of tension and revelation. They also have an emotional arc consisting of inner conflict that meshes with the narrative arc” (p. 856). Baker (2009) also notes that life history research can be demanding for the researcher as it “is not for the faint-hearted researcher and calls for much transcribing, travelling and interviewing” and “necessitates substantial interpersonal skills when arranging and conducting interviews” (p. 21). Any emotional responses were noted in the post interview checklist, held securely by Research Data Service, University of Reading (Blagrove, 2023). All ethical considerations were therefore acknowledged and the guidelines of the University of Reading’s ethical procedures in research were followed at all times.

3.10 Revisions

The pilot study of three individuals randomly selected at a community centre resulted in changing some closed questions to open questions to gain greater insight. The estimated length of interview times was confirmed suitable, as a maximum of one hour for the first interview and two hours for the second. It was noted that some interviewees did not need to be asked all the scheduled questions, as often participants would answer several questions in one long answer without the need for further qualification of life history information by the researcher. A pilot interviewee suggested that participants could pick their own pseudonyms for the study, and this was accepted if the participant requested. The post interview checklist was altered to include more questions detailing the suitability of the venue of the interviews. The pilot study resulted in adding to the participant information summary details of the most recent learning course the individual had attended. The pilot confirmed that the first interview could be used as a filter for any individual that had been thought suitable as a participant, but who subsequently appeared unsuitable for the study, for example if there was an unsuitable lack of engagement or participation during the initial interview. The study did not show participants examples of old textbooks or encyclopaedias, as sight of these may have resulted in a false memory and a false-positive identification of a source. A final alteration to the study, following the pilot, was that only one member of a

family would take part, as close family members or relations may have too similar influencing factors in their rejection or acceptance of the theories.

3.11 Summary

The life history methodology for this study was chosen after considering opposing paradigms and positions and by taking the research question as a tool. The study follows an interpretivist paradigm, epistemology and ontological framework. The ontology is connected to the research aim of studying the life paths of lifelong learners by exploring their lived experiences linked to the two scientific theories. The epistemology examines the perceived experiences of the respondents via dialogue. Studying respondents' life histories revealed significant insight into the factors that influence the acceptance or rejection of the Big Bang theory and the theory of biological evolution among the participants. The chosen paradigm enabled use of the re-emerged methodology of the life history approach. This approach enabled the study to examine the rejection or acceptance of scientific theories, not exclusively as the result of rational propositional logic, but as enmeshed within the context of life experiences. The life history approach enabled the study to infer influences via an evidence-based data capture method that stresses the biography and often multi-layered background of the participants, in order to provide data that established the factors that influenced the acceptance or rejection of the Big Bang and biological evolution. Purposive sampling established relevant participants with a variety and contrast of dimensions ensuring the participants were representative as far as possible. The individuals that were selected, using the three specified selection phases, were of various religions, genders, ages, educational backgrounds and occupations. The semi-structured format of interviews used prompting open and closed questions around the main issue of the study arising from the research question, literature review and methodology, to reveal insight into the factors that influence the acceptance or rejection of the two scientific theories. The methodology used also checked the level of understanding by the participant of the terms to be used in the research. Suitable research tools were utilised including interview venues and computer software. The checklist used after each of the twenty interviews established any potential areas of questionable reliability or validity. The guidelines of the University of

Reading's ethical procedures in research were followed at all times. The methodology provided a process designed to establish the life history experiences that have influence the participant's acceptance or rejection of the Big Bang theory and biological evolution. The twenty interview transcripts that were the result of the life history methodology provided significant amounts of raw data for coding. Baker (2009) emphasises the importance of using the participants' own words, phrases and sentences in the presentation of findings from life history research and that the findings must not present the researcher's version of words spoken by the participants but should instead use direct quotes from the interviewees as much as possible and practicable. Some of the participant quotations are therefore longer in order to retain their context.

Chapter 4: Findings concerning influences

4.1 Introduction

The presentation of findings from the twenty transcripts uses three overarching themes of influences, behaviours, (including psychological patterns) and resulting opinions. Each theme, which represents a pattern across the data, contains several codes, which capture specific segments of the theme. Within each code the participants' responses and stories are given. In this chapter the theme of influences is split into eleven codes:

- religious belief
- culture and family
- science education
- cultural or religious isolation in education
- level of education
- scientific literacy
- views of evidence
- science communication methods and disputes among scientists
- alternative discredited theories and popular culture
- political affiliation
- age and gender

The different influences, behaviours and opinions, that each individual detailed in their life history interviews, suggest no two participants' opinion formation was the same, illustrated in the following vignettes:

Figure 1. Vignette of Barbara's account

Barbara currently accepts the Big Bang theory and rejects elements of biological evolution. She grew up in both a cultural and practicing religious household. Up to the end of her primary school years she believed in a Biblical origin of the universe and life. Although now an atheist she thinks both theories are compatible with a religious belief, as a God could have used both the Big Bang and biological evolution to create the universe and life on earth over the expanse of time.

Her secondary school universalist style science education did not allow any alternative discussion during lessons. Although not having personal feelings of religious or cultural isolation in school she was aware of a fellow student at secondary school that did feel isolated and picked on, due to her religious beliefs in a Biblical creation story. During Barbara's secondary school years, her personal beliefs were changing and at points she held two views in parallel concerning the origins of the universe and life, one scientific and one religious.

Barbara could define both theories well, showing signs of scientific literacy. She considers scientists mostly agree with each other on both theories, however she is aware of the theory of Panspermia and considers elements of this plausible. Her rejection of parts of biological evolution stem from this knowledge as she considers that although evolution has taken place on earth, initial stages of evolution may have taken place elsewhere and arrived on earth via meteors. She is aware of the steady state theory but rejects this in favour of the Big Bang due to the evidence of expansion of the universe. She acknowledges the body of evidence for both the Big Bang and biological evolution.

Barbara at 45 is one of the older participants that have knowledge of former discredited theories that are no longer taught in schools. She shows no signs of avoidance of cognitive dissonance, the sleeper effect nor cognitive bargaining. However, she did show signs of confirmation bias as she admitted only watching programmes that support her views. Barbara finds both the Big Bang and biological evolution intuitive. However, she also finds the theory of Panspermia intuitive.

Her views of both theories have changed through her life, from Biblical creation up to the start of secondary school, to accepting elements of biological evolution taught during biology lessons, although rejecting other elements of the theory due to her acceptance of Panspermia. She was not taught the Big Bang at school and accepts it based on her subsequent personal study in later life after university, via reading books and watching documentaries that provided evidence to her of the expanding universe.

Figure 2. Vignette of Howard's account

Howard rejects the Big Bang and rejects elements of biological evolution. He grew up in a cultural and practicing religious household. Biblical creation of the universe and life was taught at home, primary school and in religious studies at secondary school. Evolution was taught in universalist style science lessons, but the Big Bang was not part of the science syllabus. His total rejection of the Big Bang and acceptance of a created earth contrasts with his belief in elements of evolution where, in his view, God guided evolution to create life on earth.

Howard did not feel or encounter any cultural or religious isolation at the secondary school he attended. He did however feel during science lessons that he held two views in parallel, one religious and one scientific that he felt were sometimes incompatible. In university and in later life he feels he still holds some parallel views of science and religion. Although rejecting the Big Bang and rejecting elements of biological evolution, Howard still gave factually correct definitions of both theories, showing signs of scientific literacy. He considers scientists do not always agree and thinks of them to be like politicians, having different opinions despite having the same evidence. Howard is the oldest participant at 83 and has knowledge of both the Steady State and Panspermia theories. He is aware both are not considered valid in modern science thinking. He rejects both discredited theories and prefers a mainly Biblical explanation to both the universe and life on earth. He considers there is valid evidence for elements of biological evolution but not for the Big Bang, preferring Biblical creation.

He shows signs of cognitive dissonance, saying the Big Bang does not provide a nice end to everything and he does not like the theories consequences. Similarly biological evolution does not make him feel happy as it removes humanities special place as Biblical guardians of the earth and life on it. He shows signs of conformation bias by only looking for evidence that supports his existing views. He considers this valid as in his view every human does it. He showed signs of the sleeper effect stating that following new evidence that changed his view he often then reverted back to his traditional Christian beliefs. Howard also showed signs of cognitive bargaining as his deeply held religious beliefs have altered, accepting biological evolution as part of his evolved faith. He finds biological evolution intuitive but does not accept it in full. He rejects the Big Bang and finds it neither intuitive nor counter intuitive. Howard's views have altered in his lifetime. Up to the end of primary school he believed in Biblical creation. At secondary school his belief altered to include parts of biological evolution, where God guides evolution in the creation of life. His view on the Big Bang has remained full rejection, mentioning a famous scientist from his memory that said it was wrong, although he could not remember his name. This was possibly Hoyle.

Figure 3. Vignette of Peter's account

Peter accepts both the Big Bang and biological evolution and describes himself as both a practicing and cultural Christian from childhood. Up to the end of primary school he believed the Biblical creation story. At secondary school he was introduced to biological evolution during universalist science education style lessons. He was not taught the Big Bang, that he thinks was not part of the syllabus. Following university his personal adult study introduced him to the Big Bang and he concludes both theories explain the occurrence but not the cause, that he attributes to God.

Peter was not aware of any instances of cultural or religious isolation at school. He recalls parallel learning at school between science lessons that taught biological evolution and religious studies lessons that taught Biblical creation. He believes his personal parallel learning stopped in adulthood as he now finds science and religion totally compatible. He could define both theories well, showing signs of scientific literacy. Peter believes scientists are not always in agreement and thinks science is sometimes in turmoil over some issues. However, he finds it significant that some noted scientists and mathematicians are Christian, for example Lennox.

He is unaware of other theories including the Steady State and Panspermia. He considers there to be strong evidence for both the Big Bang and biological evolution, but he also states, as theories they may one day be proved wrong. He acknowledges cognitive dissonance to both theories, but despite concerns for each, he accepts both theories as true. Peter acknowledges he does have confirmation bias as he often only looks for evidence that supports his existing views. He also acknowledges the sleeper effect, remembering occasions of receiving evidence that changes his mind, only later to revert back to previous beliefs.

He undertook personal cognitive bargaining where his religious beliefs have altered from Biblical creation to accepting both the Big Bang and biological evolution within his Christian faith, where God started both as methods of creation. He finds both theories intuitive. At 53 Peter's views have therefore changed significantly since childhood from belief in a Biblical creation to fully incorporating both theories into his Christian faith, emphasising that they explain events but do not explain cause. He accepts both theories fully as he believes they are fully compatible with his personal Christian position.

Figure 4. Vignette of Dean's account

Dean rejects elements of both theories. He is a practicing Muslim and grew up with and maintains an Islamic cultural environment. Up to the end of primary school he believed in his faith's creation story. At secondary school he was taught biological evolution in multiculturalist style science education lessons. The Big Bang theory was not on the curriculum, but he became aware of it through private study at university and in later life. He accepts elements of the Big Bang theory, but considers Allah took an active part in the creation of the universe. He rejects macro evolution, which is a part of the overall biological evolution theory.

Dean's secondary school in Egypt accepted different faiths to attend, including Christians and Muslims. The science lessons were of a multiculturalist style in nature, with open discussion of creation stories allowed. When he left secondary school he did not accept either theory. In school he never encountered religious nor cultural isolation. He held parallel views at school of science and religious belief as a necessity to pass exams. He shows strong scientific literacy, especially in his detailed knowledge of evolution. Dean is aware of evidence to support both theories. He believes scientists are at odds with each other on both theories and scientific disputes exist. He is 43 and is aware of the Steady State and Panspermia theories but does not accept either.

He shows signs of cognitive dissonance concerning both theories where the cold dark death of the universe is not compatible with Judgement and biological evolution is not compatible with the status given to humanity by Allah. He admits to conformation bias in seeking knowledge that agrees with his beliefs. He appears to show signs of the sleeper effect, saying that upon receiving evidence that changes his mind he later reverts back to pre-existing beliefs.

Dean has undertaken personal cognitive bargaining where he has incorporated some elements of both theories into his religious beliefs. He finds the Big Bang intuitive but biological evolution counter intuitive in respect of macro evolution. Dean's views have altered throughout his life from strict belief in a created universe and life, to atheism and back to belief in Allah. After leaving full time education he developed his beliefs to incorporate some elements of both theories into his faith position.

Figure 5. Vignette of Jill's account

Jill accepts both theories. She grew up in a secular household that included her father who was an atheist. At secondary school her friends introduced her to a local church that they attended, and she became a Christian. She celebrates her Christian faith at two churches, one Methodist and one Church of England, both of which contain members that accept the Big Bang and biological evolution as part of their faith. Jill believes God started both processes to create the Universe and life.

Jill attended a secondary school that undertook a universalist style approach to science lessons. However, neither the Big Bang nor biological evolution was on the school's limited curriculum. She left school at 16, although in adult life attended university. At secondary school she noted instances of student isolation if they were not religious, that she explained by stating her age and that she attended school some time ago. She did not recognise parallel learning occurred during her education, possibly because the two theories were not on the curriculum.

She can define both theories well and shows good scientific literacy. She knows of the significant body of evidence for both theories. Jill believes scientists disagree with each other on both theories and knows of both the Steady State theory and Panspermia theory, possibly because of her age at 69. Despite showing cognitive dissonance to both theories, she accepts them within her Christian faith. She shows no sign of confirmation bias nor the sleeper effect.

Jill did show signs of cognitive bargaining that allows both theories to be fully part of her faith in God. She finds both theories intuitive and the means by which God acted to create the universe and life. Her beliefs have changed considerably over her lifetime from pressure from her father to accept atheism, to a Biblical belief in creation, to accepting and accommodating both theories as part of her faith in later life.

Figure 6. Vignette of Ella's account

Ella fully accepts both theories. She grew up as part of a cultural and practicing Catholic family in which she was taught and believed Biblical creation from an early age. Her family never discussed scientific theories. Her primary and secondary school education was undertaken at two faith-based Catholic schools.

Her secondary school undertook a multiculturalist style science lesson format, teaching both the Big Bang and biological evolution. At secondary school she remembers being informed by her science teacher that it was possible and acceptable to be both a practicing Catholic and believe in both theories as part of God's method of creation. Ella remembered a Catholic priest was involved in the formation of the Big Bang theory and that the Pope had said both the Big Bang and evolution had occurred as part of God's creation of the universe and life within it.

Ella never encountered cultural nor religious isolation at school and did not hold parallel views of religion and science at school, as she believed both God and the two science theories were totally compatible. She could describe both theories well and showed strong scientific literacy with good knowledge of evidence for both the Big Bang and biological evolution. She was unaware of any scientific disputes and was similarly unaware of either the Steady State theory or Panspermia theory, possibly due to her age, being the second youngest participant at 19.

Ella showed no signs of cognitive dissonance, confirmation bias nor the sleeper effect in respect of either theory. She did show signs of cognitive bargaining in that her Catholic faith was maintained in plausibility by deliberate modification, from Biblical creation to creation via God's use of the Big Bang and biological evolution, both of which she finds intuitive. Her views have therefore changed over time from Biblical creation to acceptance of both theories within her Catholic faith.

Figure 7. Vignette of Josh's account

Josh accepts both theories. He grew up in a cultural and practicing Hindu family. At home and at primary school he believed his religion's creation stories. At primary and secondary schools, he studied both theories in universalist science style lessons. He found he accepted both theories by compartmentalizing, in parallel, his religious beliefs and science in his mind. He found he was at an advantage in this respect due to the number of different stories in his religion that can be compartmentalized due to their incompatibility with each other. He found his religion an aide to accepting scientific theory as Hinduism is accepting of different beliefs, which can be contradictory. At school Josh did not come across any instances of cultural or religious isolation.

Josh could define both theories well and had good knowledge of evidence of both, showing signs of scientific literacy. He does not consider scientists are at odds with each other and he believes they agree on the validity of both theories. At 18 he was the youngest participant and had no knowledge of alternative theories, including the Steady State and Panspermia theories.

He showed no signs of cognitive dissonance, confirmation bias, the sleeper effect nor cognitive bargaining. His religious beliefs have not changed during his life, and he found it easy to accept both the Big Bang and biological evolution. He has not altered his acceptance of these theories.

Figure 8. Vignette of Sue's account

Sue accepts both theories. She grew up in a secular family and attended secular schools that did not teach religious creation stories. She was not religious nor culturally religious. She became a Buddhist in her 20s and believes Buddhism does not teach nor contradict science. Therefore, in her view most Buddhists accept the Big Bang and biological evolution.

At school Sue was taught science in a universalist style format, learning about biological evolution. The Big Bang was not on the science syllabus, and she learnt about it through private study and watching science documentaries. She did not encounter any religious or cultural isolation in school. She did not experience any form of parallel learning at school or during private study as she considers Buddhism to be compatible with the two scientific theories.

She gave good definitions of both theories and showed signs of scientific literacy with knowledge of evidence for both theories. She is aware that scientists disagree in many areas but has no knowledge of either the Steady State or Panspermia theories, possibly because she is a younger participant at 31. Sue did not show signs of cognitive dissonance, confirmation bias, the sleeper effect nor cognitive bargaining, and finds both theories intuitive. Her views have changed over her lifetime going from secular to Buddhist and from no scientific knowledge to accepting both theories due to school and private study.

Figure 9. Vignette of Ann's account

Ann rejects both theories. She did not grow up in a religious family nor culture. However, at school she was taught a religious explanation of the universe and life. In adulthood she does not follow any religion and does not know if God exists. Her rejection of both theories is due to her knowledge, at 72, of other theories, including the Steady State and Panspermia, that she considers possible, having knowledge of them from different periods of her lifetime and different sources.

At school, during universalist style science education lessons Ann did not notice any cultural nor religious isolation. She may have experienced parallel learning at secondary school being taught biological evolution, while believing for a period in Biblical creation.

Ann could define both theories but believes not all scientists accept them. She does not think there is enough evidence to fully support either theory. Ann does not show signs of cognitive dissonance nor cognitive bargaining but does show signs of confirmation bias and the sleeper effect. She does not think the Big Bang and biological evolution are intuitive. Her views have changed over her lifetime from no belief to Biblical creation, to the Steady State and Panspermia theories.

Figure 10. Vignette of Roger's account

Roger rejects both theories. He grew up in a religious household where he was taught Biblical creation at home and at primary school. This belief continued into secondary school and into adulthood. He considers himself both a cultural and practicing Christian.

At secondary school he was taught in a universalist style science education format and retained his Biblical creation beliefs throughout. He felt isolated during science lessons due to his personal beliefs in the Bible and in his view its incompatibility with the Big Bang theory and biological evolution. He felt he had to hold parallel views to pass exams.

Roger could define both theories and showed signs of scientific literacy, but believes scientists disagree on the origins of the universe and life. He does not think there is conclusive proof of either the Big Bang or biological evolution. Although 52, he has no knowledge of other theories, including the Steady State and Panspermia.

He showed no signs of cognitive dissonance, the sleeper effect nor cognitive bargaining. He did show signs of confirmation bias, in particular sighting a creation ministry DVD as evidence of his beliefs. He does not think the Big Bang and biological evolution are intuitive.

His views of Biblical creation and the two scientific theories have never changed. His deeply held religious views of creation and the validity of the Bible result in his rejection of the theories. He considers them fundamentally flawed and incompatible with being a Christian.

These accounts suggest each life history brings with it different influences and behaviours, with no two life histories being the same. This is illustrated by the unique responses that each participant gave during their interviews:

4.2 Religious belief

Findings from the twenty transcripts noted that in some instances, for example Jill, religious belief may be a significant influence for why the interviewee accepts the two scientific theories, as both theories help her explain God and creation in logical terms. For other interviewees, for example Roger, religious belief has contributed to their rejection of both theories, as he believes in the Biblical creation story. Those participants that are atheists, or of no religious belief, also have contrasting opinions. Ann has no religious affiliation and yet rejects both theories and Barbara, who is an atheist, only accepts parts of evolutionary theory.

Jill explained that she grew up in a home environment where her father held anti-religious views:

> *My father was an absolute atheist, and he would not have anything to do with church …. When I was in my third year at secondary school it just so happened that in my form group there was a girl who came from generations of Methodists …. My mum was, like the majority of the population, with some vague idea that there probably is a God …. I became a member of the Methodist church and that's how things progressed from there.*

Jill stated that she attends and occasionally leads worship at two Christian churches, both of which allow members to make their own minds up about the two scientific theories, as part of their faith. Jill confirmed that both churches do not instruct acceptance or rejection of the theories upon leaders or attendees:

> *Within Methodism and the C of E it is very broad …… You can accept both theories and be a Methodist or member of the Church of England ……. The first Methodist minister I worked with said I was anti-Bible. I am not anti-Bible at all. I think there are different ways of looking at the Bible. I said to him what about fossils? Yes, you can believe in God and be a Christian and accept the Big Bang and evolution.*

Jill revealed that she accepts the Big Bang theory:

I accept it. I see God standing outside of time and there was a point when our Creator God set things in motion. I don't like the Genesis six-day creation story because I don't think God is in a hurry like we are.

Jill said she also accepts the theory of biological evolution:

I accept it. Again, God is not in a hurry. This is a world in process and in progress. We are so egotistical, we say we are top of the tree. Who knows what phases comes next. There will be more changes, biological and whatever in the course of time.

Jill explained that she believes in God, Christianity and both scientific theories despite her childhood home environment providing little input in any of these areas. Neither her primary nor secondary schools were faith based, but they did have Christian based assemblies.

Peter describes himself as both practicing Christian and culturally Christian from childhood and accepts both the Big Bang theory and the theory of biological evolution. Like Jill, Peter confirms some Christians and other theists accept both theories without difficulty. As a young child he recalled being read Biblical stories of how the world and life were created. Peter explained that his Biblical creation beliefs, held before starting school, were reinforced in his primary education where he was taught the universe, and all life were created by God. At secondary school he was taught creation in religious studies lessons and assemblies but was taught evolution in his science lessons. The Big Bang was not taught, possibly because it was not part of the science syllabus. As with Jill, Peter in adult life finds no conflict in being a Christian who can accept both scientific theories of the Big Bang and biological evolution. He explained:

It does not put me at odds with my Christian beliefs. God could have started both the Big Bang and evolution. I am prepared to work with scientific theories and with the Bible ……. They are theories that can be proved wrong at any point in the future. We can see evidence of evolution ……. There is not a strong line taught [in church]. Within my church there are some who are convinced God created the world in six days …… they say it's got to be that otherwise all the rest falls apart, in terms of Biblical theology. Others say no there is plenty of space for an understanding of evolution

and the Big Bang, the world and life had to start somehow and there is evidence of dinosaur bones, some like to explain them through the Flood in early Genesis, others happily accept there is a scientific rational, and we work our Christian understanding through that.

He believes it is possible to believe in God and accept the theories of the Big Bang and biological evolution and he gave his personal reasoning:

Evolution and the Big Bang explain the occurrences, but not the causes. Some say you can exclude God, others say God started it off. God operates on a different level, in terms of initiative and reasons. The occurrences can be explained if God initiated them ……. Most people want to accept the Big Bang because it fits scientific evidence. They want an explanation for the origins of life ……. Some people reject it because they feel threatened that there is an explanation without God. But God may well have used these methods to set the world and universe up and running ……. There is a sense of threat because we don't get told about evolution or the Big Bang in the Bible.

In contrast to Jill and Peter, Howard's religious background and beliefs played a part in his rejection of the Big Bang and his rejecting parts of biological evolution. Howard gave his account of growing up in a Christian household where his parents and siblings believed in the Biblical creation story and taught it to him. This family background probably influenced Howard's current scepticism of the two science theories, especially as the family Christian background of Biblical belief was reinforced at his primary and secondary schools, where Biblical creation was given as the origin of both the universe and life. At secondary school Biblical creation was taught in religious studies lessons and evolution in science lessons that resulted in a change in his belief to:

God created the universe and God played a part in evolution.

Roger described his own deeply held religious beliefs that in his view require him to reject both theories:

I believe in what is in the Bible …… I grew up with my parents and brother. We are all Christian.

His earliest memory is being read a children's' Bible. At primary school he was taught biblical creation that he continued to believe in his secondary school. He does not believe the theories are compatible with his faith and religion:

> *Some people think you can be a Christian and accept the theories, but that is wrong. I believe in what is in the Bible …… I like David Attenborough. I think he is good, and I think with age he has changed his mind on things, like the chap from Reading University, Professor Flew. He changed his mind and went from being an atheist to believing in design by God of the universe and life. I also have a DVD set on creation from Creation Ministries.*

He does not think it is possible to believe in God and accept the theories of the Big Bang and biological evolution:

> *You should believe in one or the other. If you are a Christian you should believe in the Bible and creation …… God created the universe, as it says in the Bible.*

Barbara described growing up in a Christian household where she read her family Bible to herself as a child. She is not certain of her parents' views on the two theories:

> *Science wasn't something that was discussed in our house particularly, but as my parents both met at Sunday School, I would imagine theirs was more of a Christian view …… We had a Bible that was a big deal. A big, illustrated children's Bible. At home. To me it was like the size of an encyclopaedia, but whether it was or not. It was reasonably tatty, so I presume it was what my older siblings had. I would look at the pictures and read it to myself. I read about the creation story.*

As a child, before starting school, Barbara accepted the Biblical creation of the universe and Adam and Eve as true. At primary school Barbara was taught and continued to believe a Biblical origin of the universe and creation of humans:

> *I believed what I was told about both from the Bible.*

Despite believing in Biblical creation in childhood and having a Christian cultural childhood, Barbara now accepts the Big Bang theory fully and accepts parts of the theory of biological

evolution. Although now being an atheist, Barbara thinks religious belief and science are compatible:

> *I think people that believe in God can believe God started the Big Bang, or created the Big Bang and that God started evolution off.*

Dean stated that he is a practicing Muslim and grew up within a Muslim household. He rejects elements of both theories, initially describing his family upbringing:

> *My parents are normal people. They are not scientists. Religiously they are normal. My father does not have a beard. They are cultural Muslims. They believe God is one …… you could believe what you believe …… They [his siblings] are similar to my parents. Some of them are culturally Muslim. Some are Muslim. Some yes, some no. Allah has a wisdom, and everyone makes his choice, and he will be accountable for his choice.*

He remembers before starting school he was often read or told stories of the creation of the universe and life, that he believed. Both his primary and secondary schools were faith based, illustrating the influence of religion in these years, where he was taught, and accepted accounts of creation given in the Qur'an. At secondary school the Big Bang was not part of the curriculum, although evolution was:

> *We would ask the teacher how is this [evolution] true, they would say this is a very well-known scientific theory. We had discussions and could talk about creation. We did have to know evolution to get good marks. But I did not believe it.*

Dean explained that he accepts only parts of the Big Bang theory that he finds compatible with the Qur'an:

> *In terms of logical theory there was nothing and then the universe came and expanding. It makes sense. But it's a theory and it can change obviously. There are some scientists that reject it. To be honest it's a theory. It is in the Qur'an.*

He also rejects parts of the theory of biological evolution:

Micro evolution, which is adaptation can happen. But Macro evolution I do not accept. I believe Allah created Adam by His hands.

He believes that his religion can allow a wide range of beliefs about both science theories:

Different Muslims believe different things. Some think the Big Bang and evolution are right. Some think they are wrong.

Ella described growing up in a Catholic family where she was taught and believed Biblical creation of the universe and life at an early age. The family never discussed science. Her primary and secondary were faith-based Catholic schools. At primary school Ella was taught Biblical creation. At secondary school Ella was first introduced to both the Big Bang theory and theory of biological evolution as part of the school's Catholic faith-based education:

We did a project on it. The Big Bang. It was a Catholic priest that figured it out. Can't remember his name …….. We were taught evolution in biology lessons ……. We talked about God in science lessons sometimes. The teacher said God maybe started the Big Bang and evolution. I think God did do that too.

In adulthood Ella finds no difficulty in being a Roman Catholic and accepting both theories:

I think the Pope said they happened. I think it's ok to believe in them if you are a Catholic …… God started the Big Bang and then he started evolution …… I believe in the Big Bang and evolution. But when I was young I didn't.

Josh gave his account of growing up in a practicing Hindu family where he was told creation stories at home and at his Temple from a young age. At primary school he continued to believe the religious creation stories. However, Josh at secondary school and beyond successfully compartmentalised in his mind his religious beliefs and his acceptance of the two scientific theories:

You kind of keep them apart. The creation stories in my religion are different to science. Science is different. You kind of have two boxes in your mind. You put your religion in one and the science you are taught in the other. As a Hindu you kind of

have boxes in your mind already because we have so many different stories of creation.

He believes his religion is not overly concerned about the Big Bang or biological evolution:

It depends on who you speak to. Different Hindus believe different things. You can accept science and the Big Bang and evolution and be a Hindu. That's not a problem. It's not a religion that says you can only believe one thing that is in one book and that's it. You can believe what you want ……. There is no problem in being a Hindu and accepting science. I am a Hindu and I also believe in science.

Sue revealed that she grew up in a secular family environment and secular school environment that never discussed religious stories of creation or religious origins of life. She does not consider that she was religious or culturally religious. In her 20s she became a Buddhist. She accepts both theories:

It [Buddhism] does not teach about science ……. I think most Buddhists are ok with evolution and the Big Bang.

Ann said she does not hold any religious belief and did not grow up in a religious family environment. However, today Ann rejects both theories. During her school years Ann remembers being taught that God created both the universe and life:

At that time, in secondary school, I guess I believed in God, and he created everything.

Ann does not give this as a reason for her rejection of both theories as she does not follow any religion and does not have a fixed view on the existence of God:

I think most religions are a load of rubbish. No time for them.

Instead, Ann gives other reasons for rejecting both theories, including the existence of other theories:

It all sounds a bit farfetched to me [the Big Bang]. It's a bit like God. What made God? What made the thing that made God? It's the same with the universe. What made the Big Bang? What made the thing that made the Big Bang? It's all ideas and

theories. No one really knows. It's all guesswork ……. There are too many gaps [in evolution]. I saw a book the other day that said humans may have come from space. If they did then they did not evolve. They arrived. So, no. It's just another idea. All guesswork.

Findings do appear to link the rejection and acceptance of the two science theories to religious belief among some participants. With some participants their religious belief is a direct reason why they accept both theories, as the theories can help explain, in the view of some participants, God's existence and God's methods of creation. In other participants religious belief is a direct reason to reject both theories due to a literal belief in a faith-based creation story. Participants that have no religious belief, nor belief in God, also describe a mixture of opinions, where some do not accept either theory.

4.3 Culture and family

Culture is, in the context of this study, the shared customs, traditions and meanings of a group of people (Punch, 2005). An individual's culture is not necessarily acquired at birth and can be acquired or recognised in later life and can change during one's lifetime. Based on the participant interviews, unlike religious belief, culture does not by itself appear to impact on the acceptance or rejection of either theory, unless both the individual's culture and religion are inextricably linked. The individual participants' accounts illustrate the variation among those interviewed:

Barbara describes herself in adult life as not being culturally Christian and is an atheist. She rejects parts of biological evolution and accepts the Big Bang. Although she does not consider herself culturally Christian in adulthood, she grew up in a culturally Christian family:

My parents both met at Sunday School ……. We had a Bible that was a big deal. A big, illustrated children's Bible. At home ……. It was reasonably tatty, so I presume it was

what my older siblings had. I would look at the pictures and read it to myself. I read about the creation story.

Howard considers himself as both a Christian and culturally Christian and rejects parts of biological evolution and rejects the Big Bang. His cultural Christianity was enhanced by his faith based primary and secondary schools, including by their assembles:

They [primary and secondary school assembles] were the same. The Headmaster would talk. There would be a Bible reading and a hymn. Then it would end with a prayer.

Peter describes himself as both a Christian and culturally Christian. Peter accepts both theories. He emphasised his parents and wider family in his personal cultural background:

We were all root Christian, but we were not heavy church goers as kids. My father would have looked to the Bible.

Dean explains how, for himself, being culturally Muslim is totally different to being a Muslim. Dean rejects parts of both theories:

I was culturally Muslim when I was younger. I am not now. I am now a Muslim.

Jill describes herself as not being culturally Christian due to her childhood, where she was surrounded by anti-religious parenting by her father and other family members. However, she is now a practicing Christian and accepts both theories:

Let me tell you about this [culture]. My father was an absolute atheist and he would not have anything to do with church. His constant theme song was 'bloody bible thumpers bloody hypocrites'. He wouldn't have anything to do with religion at all.

Ella considers herself culturally Christian and a Catholic. Although she grew up culturally and religiously believing in Biblical creation, following secondary school she now accepts both scientific theories within her Catholic faith and culture:

We talked about God in science lessons sometimes. The teacher said God maybe started the Big Bang and evolution.

Josh describes himself both as a cultural and practicing Hindu and accepts both science theories:

Being a Hindu is more about trying to be a good person [than accepting science].

Sue does not consider she is, nor ever was, culturally Buddhist. Although she accepts both theories, she describes herself as an agnostic Buddhist concerned with reducing suffering in the world and sees her view of Buddhism as different from both culture and science:

I converted to Buddhism some years ago. I am not culturally anything.

Ann describes herself as culturally British and not culturally religious. She rejects both theories:

I think most religions are a load of rubbish ……. I am culturally British.

Roger considers himself both culturally and practicing Christian and he rejects both theories:

I grew up with my parents and brother. We are all Christian.

Based on the study data, family and culture do not appear to impact views of either theory in a consistent way. Some participants hold the same views as parents, for example Roger, while others have opposing views to parents, for example Jill. Within families, parents and other family members may have opposing views on many issues. Although in early years, especially pre-school and primary school years, family beliefs may influence childhood beliefs, for example Roger, no participant gave their parents' or family views as the reason for their rejection or acceptance of either scientific theory in adulthood. Findings suggest that culture does not by itself appear to impact on the acceptance or rejection of either theory, unless both the individual's culture and religion are linked. Similarly, family does not have a consistent impact on the participants' views.

4.4 Science education

The study found that two participants had been taught science at secondary school using methods similar to multicultural science education, (Dean and Ella) and eight had been taught using methods similar to universal science education, based on their description of the science lessons they attended, (Barbara, Howard, Peter, Jill, Josh, Sue, Ann and Roger). At primary school science was not taught in dedicated science lessons. Of the eight participants that were taught science at secondary school in a universal science education style, there was a mixture of acceptance, partial rejection, and total rejection of both theories. The two participants that totally rejected both theories, (Ann and Roger), were educated using universal science education style practices. Of those participants that had been taught science in multicultural science lesson styles one accepted both theories (Ella), and the other rejected elements of both theories (Dean).

Ella described being taught science at a Roman Catholic secondary school using a format similar to multicultural science education, where students were allowed to discuss in science lessons all forms of creation belief as well as scientific theories. No restriction was made on student and teacher discussions in the science lesson concerning either the origin of the universe or origin of life. Ella currently accepts both theories:

> *We talked about God in science lessons sometimes. The teacher said God maybe started the Big Bang and evolution. I think God did do that too.*

Ella's primary school taught faith-based creation stories and she had grown up in her pre-school years being read Biblical creation stories:

> *God created the world and Adam and Eve and then there was the flood. All the animals going in two by two.*

At secondary school Ella first encountered scientific theories within a format similar to multicultural science education. The school was faith-based although her religious studies lessons did not cover Old Testament Biblical creation. The science lessons also taught Lemaitre's contribution to the Big Bang theory:

We did a project on it. The Big Bang. It was a Catholic priest that figured it out.

As Ella was taught in a format similar to multicultural science education, the free flow of mutually respectful beliefs and opinions may have contributed to her accepting both scientific theories of the Big Bang and biological evolution within her Catholic faith. Her secondary school education was undertaken within a faith-based school environment that appears to have been understanding of personally held beliefs and opinions.

Dean described being taught science at a Christian school in Egypt using a format similar to multicultural science education where students were allowed to discuss in science lessons all forms of creation belief and science theory. No restriction was made on student and teacher discussions in the science lesson concerning either the origin of the universe or origin of life. Dean currently rejects elements of both theories:

> *We had discussions. We would ask the teacher how is this true, they would say this is a very well-known scientific theory. We had discussions and could talk about creation. We did have to know evolution to get good marks. But I did not believe it.*

Dean's primary school only taught faith-based creation from the Qur'an. During these primary school years, he believed creation was the origins of the universe and humanity. His secondary school was faith-based and taught creation in religious studies lessons. During his secondary school years, he continued to believe creation was the origins of the universe and humanity:

> *I did not believe in evolution. I believed in creation of the universe and Adam.*

As Dean was taught in a format similar to multicultural science education, the discussion of mutually respectful beliefs and opinions may have contributed in adulthood to his acceptance of some elements of both scientific theories of the Big Bang and biological evolution within his Muslim faith.

Ann was taught science at secondary school in a universal science education style format that she explained did not allow debate of other explanations of life and the origins of the universe, for example religious explanations. At secondary schools Ann recalls being taught religious creation stories. During her school years Ann thinks she believed God created the

universe and life. At secondary school Ann had science lessons on evolution but not the Big Bang, which may not have been on the science curriculum. Ann's rejection of both theories may be attributed to her own private study and interest after she left school, where she came upon other scientific theories and controversies, mainly via television documentaries and books that she read during and after attending school:

> *Many years ago, I think I remember that [the Steady State theory] …… another theory [Panspermia] that's about life coming from space. Could have happened ……. I remember a book about life coming from comets and recently I remember a book about an animal in the sea coming from space. I cannot remember if it was a squid or octopus. Then I read recently that humans could have come from space. It's all possible. You never know.*

Roger explained that he was also taught science at secondary school in a universal science education style format that did not allow debate of other explanations of life and the origins of the universe. Today Roger rejects both the Big Bang theory and the theory of biological evolution. Roger's universalist secondary school science lessons however may not be a contributing factor in his rejecting both theories. Roger's rejection may be attributed more to his deeply held religious beliefs that categorically reject both theories, in line with his evangelical Christian viewpoint of Biblical creation. Before he was taught both theories at secondary school Roger only believed in Biblical creation and after being taught the theories, he retained his religious beliefs about creation by God.

Barbara said she was taught science at secondary school in a format similar to universal science education that did not allow debate of other explanations of life and the origins of the universe. Today Barbara accepts the Big Bang theory and rejects elements of biological evolution. However, at primary school Barbara was only taught religious explanations for both the universe and life on earth and consequently:

> *I believed [at the time] what I was told about both from the Bible.*

Primary school morning assembly consisted of:

A Bible story or story with a meaning to it and a hymn and a prayer. One of the hymns we sang at primary school was "When God made the garden of creation". The hymns and prays had creation stories.

Despite being taught science in a universalist style format at secondary school the morning assemblies were the same as primary school:

Prayers and hymns with creation stories in them.

Barbara's secondary school science lessons were of a universalist science education format, and today Barbara accepts the Big Bang theory fully but rejects aspects of the theory of biological evolution.

Howard's secondary school science lessons were also of a universal style science education format not allowing non-scientific explanations to enter the lesson revealing that in his experience:

They were science lessons. You never discussed religion in science lessons.

Howard today, unlike Barbara, does not accept the Big Bang theory and rejects elements of the theory of biological evolution:

Because the universe has always been here. There was no Big Bang. God played a part in evolution. He started it and looked after it.

This may reflect Howard's primary education where belief in Biblical creation was taught and when asked what he believed at this age he responded:

I believed what is in the Bible. The Book of Genesis.

Howard's secondary school, although teaching science in a universal style format had a Biblical emphasis at times, for example, when comparing secondary and primary assemblies:

They were the same. The Headmaster would talk. There would be a Bible reading and a hymn. Then it would end with a prayer.

During his secondary school years, he continued to believe in creation:

God created the universe and God played a part in evolution, I think.

Howard's partly accepting some elements of the theory of biological evolution, and his dismissal of the Big Bang theory may be linked to the Biblical creation story taught to him at both primary and secondary school. The Big Bang was not taught in any of Howard's science lessons as it was probably not part of the curriculum.

Peter's secondary school science lessons were also of a universal style science education format not allowing non-scientific explanations to enter the lesson and today Peter accepts both the Big Bang theory and the theory of biological evolution:

> *It does not put me at odds with my Christian beliefs. God could have started both the Big Bang and evolution. I am prepared to work with scientific theories and with the Bible …. They are theories that can be proved wrong at any point in the future. We can see evidence of evolution.*

This is despite Peter's primary education where belief in Biblical creation was taught. When asked what he believed were the origins of the universe and life during his primary school years he replied:

> *I don't recall questioning what I was taught at that stage at all. So Biblical.*

Peter's secondary school, although teaching science in a universal style format had a similar Biblical emphasis at times:

> *There was a formal Anglican link [to the school]. I was confirmed as Anglican during that time. I didn't at that time question evolution.*

The Big Bang was not taught in any of Peter's science lessons as it was probably not part of the curriculum at that time. Peter's acceptance of both theories is despite the religious link of both his primary and secondary school had to the local Anglican church that aided the schools, where he was taught Biblical creation.

Jill's secondary school science lessons may not be a contributing factor in her accepting both the Big Bang theory and the theory of biological evolution, as neither theory was taught in Jill's science lessons before she left school at 16. When asked if her secondary school science lessons or religious studies lessons allowed debate about any explanations of life and the universe she replied:

No. We were never allowed to talk in lessons. The modus operandi at the grammar school was the teacher would stand at the front, would tell you what you needed to know, and you wrote notes that you then used for the homework project, or you wrote notes, and you did a little experiment. Talking was frowned upon, and it was even frowned upon to put up our hand to ask a question.

Josh was taught science at secondary school in a universal science education style format that did not allow debate of other explanations of life and the origins of the universe, for example religious explanations. Josh stated that he now accepts the Big Bang theory and accepts the theory of biological evolution. As a young pre-school child Josh was only taught traditional Hindu explanations of the origins of both the universe and life. At primary and secondary schools Josh had primary school projects and secondary school science lessons on both the Big Bang and evolution. This consistent science curriculum in both schools may have been a contributing factor in his accepting both theories today.

Sue was taught science at secondary school in a universal science education style. Today Sue accepts the Big Bang theory and accepts the theory of biological evolution. As a young child and at both her schools Sue does not recall being taught any religious creation stories. At secondary school Sue had science lessons on evolution but not the Big Bang, which may not have been on the science curriculum. Only having left school did Sue learn about the Big Bang from science programmes:

I think the ones by Brian Cox are the best.

Sue's secondary school science lessons were of a universalist science education style format, and this may also be a contributing factor in her accepting the theory of biological evolution. However, Sue's acceptance of the Big Bang can only be attributed to her own private study and interest after she left school, as it was not on the school curriculum.

Findings concerning universal and multicultural science education did not provide a conclusive link between the acceptance or rejection of the two science theories and a universal or multicultural science teaching style. As rejection of either theory or rejection of parts of either theory occurred with recipients of both teaching styles, neither method can be suggested more beneficial in ensuring acceptance of either theory.

4.5 Cultural or religious isolation in education

Findings from the study indicated instances of religious or cultural isolation within some education practices that used teaching methods similar to universal science education. Religious or cultural isolation during education are feelings of isolation in lessons or in the educational establishment, due to a student's religion or culture that can be found in ethnically, culturally or religiously diverse classes of learners (Biggs and Tang, 2011). Feelings of religious or cultural isolation can result in educational underachievement of groups or individuals (Kiwan, 2012). There were no instances of cultural or religious isolation noted among participants that attended science lessons with similar styles to the multicultural format.

Howard, Peter, Dean, Ella, Josh, Sue and Ann did not feel any cultural or religious isolation in their school. They attended a mixture of faith-based and non-faith-based school and for these participants neither type of establishment appears to have created feelings of isolation, as far as the participants could remember.

Barbara's secondary school science lessons did not allow debate about other explanations of life and the universe other than scientific theories and possibly as a result there were feelings in lessons of religious isolation in her school:

> *The school just wanted to crack on following the curriculum. There was no room within the curriculum content, as I understood it, for people to cry and feel their beliefs had been torn to pieces.*

This was also evident in Barbara's religious studies class where she said:

> *There was one member of the class at A level, when we looked at the Old Testament in terms of how it was put together and not as the word of God, how it could have been historically put together by real people. There was one person who found that offensive and would cry and she was kind of asked to stop crying, rather than being allowed to express her own beliefs.*

When asked if she ever felt culturally isolated or religiously isolated in lessons at any school or college she replied:

> *Not me. She [the other student] definitely felt religiously isolated in lessons, because eyes were rolled at her reaction, because I would imagine the majority of the class did not have a belief particularly.*

When Jill was asked if she ever felt culturally isolated or religiously isolated in science lessons at school she replied:

> *No. It was never really an issue. It was assumed everybody was vaguely Christian. But the culture going back 55 years, people were more leery [if] they weren't church goers.*

This suggests there may have been isolation if the individual was not religious during this period of the mid-20th century in England, as opposed to isolated if religious by the end of the 20th century.

Roger confirmed that he did feel religiously isolated in science lessons at school:

> *Yes, and so did my children when they were at school. We all believe in the Bible. It depends I guess on if your teacher has a faith too. Teachers tend to have quite strong views on this. The teacher puts into the lesson their viewpoint and sometimes knows they are doing it. It happened with my son. In the end they [Big Bang and evolution] are theories, but they teach them as a fact. That's not right. You end up just not talking in science lessons, so people don't look at you.*

Findings suggest instances of religious or cultural isolation within some education practices that used teaching styles similar to universal science education. Cultural or religious isolation may influence the acceptance or rejection of the two science theories as it can result in the non-engagement of the student in the lesson, for example with Roger and his children.

4.6 The level of education

Levels of formal education did not provide a conclusive link to acceptance or rejection of the theories. The two individuals that rejected both theories outright, (Ann and Roger), did not attend to tertiary level education. Within their secondary education they both did not study science after 16. However, three others that did not attend tertiary level, (Ella, Josh and Sue), accepted both theories. Further, of the five that attended university, (Barbara, Howard, Peter, Dean and Jill), there was an inconclusive mixture of acceptance and rejection of both theories.

4.7 Scientific literacy

Within the sample there were no significant signs of scientific illiteracy. The sample contained participants that rejected and accepted the theories, all of whom showed some signs of scientific literacy. Scientific literacy is the "knowledge of the concepts and theories of science" (OECD, 2015, p. 3) and all participants could define both the Big Bang theory and theory of biological evolution to at least a basic level. However, no two definitions provided were exactly the same, and all participants had their own way of expressing the definitions, some emphasising aspects of evidence that they could remember, some using illustrative hand gestures and others mentioning God as the cause of both:

Roger rejects both theories and defines each theory as:

> *[The Big Bang theory] I think some scientists would say billions of years ago the universe started from a big bang [hand gesture of expansion] and eventually the earth was formed.*
>
> *[Biological evolution] Kind of molecules to man. Evolution of animals eventually getting to humans. Genetic changes along the way.*

Ann also rejects both theories, describing them as:

> *[The Big Bang theory] It's an idea that some scientists have come up with. They think it's the start of the universe and there was a big bang …... [but] …... they disagree all*

the time ……. What made the Big Bang? What made the thing that made the Big Bang? It's all ideas and theories. No one really knows.

[Biological evolution] Some scientists think that humans evolved from some monkey or apelike creature. And other animals evolved from other animals long ago.

Barbara rejects elements of the theory of biological evolution, while accepting the Big Bang theory. Barbara was asked to define both theories and she replied:

[The Big Bang theory] The point at the beginning of the universe where there was nothing. Then a rapid expansion of particles, that is still expanding.

[Biological evolution] Living things becoming more dominant and adapted to survive best and passing on those characteristics to the next generation. And all living things are related to each other.

Howard also rejects elements of biological evolution and rejects outright the Big Bang, providing the following definitions:

[The Big Bang theory] An explosion at the start of time. Everything coming from a small point. It's still getting bigger.

[Biological evolution] Everything evolving from previous forms. Survival of the fittest. Darwin's theory of natural selection.

Dean rejects elements of both theories. Dean defined both theories:

[The Big Bang theory] It is a theory. Expansion. There had to be a start of the universe. It is a theory.

For me Darwinian evolution is a theory. It is just a theory. There are many scholars who say it is completely wrong. There is micro and macro evolution. If you say adaptation. Adaptation is part of the DNA. There is a Gnome for everyone. There is adaptation. Micro, which is adaptation can happen. It's not a big deal. But Macro I do not accept. There is no evidence for it. In terms of Darwin there are variations in the theory and gaps and not all scientists agree …….. Gravity is a fact. You can measure everything about it, but Darwin is still a theory. Micro evolution can happen.

Jill took a different view to Dean and said she accepts both theories, described by her as:

> *[The Big Bang theory] I would say thinking back billions of years there was not anything except something very very tiny that contained all the seeds of everything. To me it's a bit like a seed germinating and 'bumph' and out it comes. And the universe is still expanding. And that's how I have a real link with my God because the God I believe in cannot help creating …….. therefore, you have to believe that the universe is expanding because that's His whole nature.*
>
> *[Biological evolution] I would say that species, animals, all kinds of life and creatures have adapted over time to their circumstances and therefore they have changed biologically over all that long period of time, adapting to their environments.*

Ella also accepts both theories and defines them:

> *[The Big Bang theory] We did a bit about it at school. Everything started off like this [hand gesture of something very small between her thumb and first finger] and then it kind of went bang and got bigger [hand gesture using both hands from being together to both hands arm's length wide apart]. And it's still getting bigger. They thought that it might go back but now they think it will keep going.*
>
> *[Biological evolution] We did that in school too. It's kind of how things evolved from their ancestors over millions and millions of years. So, birds evolved from dinosaurs and humans evolved from apes or something. The more they changed the better and stronger they were. And animals that didn't change colour could be seen and so could be caught easily. So, animals that changed survived. That's survival of the fittest.*

Josh accepts both theories, describing them as:

> *[The Big Bang theory] It's how the world and universe started. Everything was together, small and together. Then it exploded and kind of went everywhere, in all directions. Then the stars and planets formed. And galaxies.*
>
> *[Biological evolution] That comes from Charles Darwin. Everything that lives can trace back to one thing at the start. So, if you take us and go back and you take*

another animal and go back, we will have the same ancestor. Over time some types of animals die out and the ones that don't die out keep going and survive.

Sue also accepts both theories and defines them:

It's a theory of how the universe came to be here from a Big Bang [uses her hands to show getting bigger].

[Biological evolution] That's another theory. It's the theory of how living things have evolved over millions of years from other living things that are now extinct.

Peter accepts both theories, describing them as:

[The Big Bang theory] The world must have started somehow. I think God started the world, including possibly by a Big Bang type of event. Expanding. It does not put me at odds with my Christian faith.

[Biological evolution] We can see evidence of evolution scientifically. Evolving. Moths in the industrial revolution. The darker ones did better than the lighter coloured ones because of the soot.

Findings linked to scientific literacy suggest that within the sample there were no significant signs of scientific illiteracy and yet the sample contained participants that rejected and accepted the theories, all of whom showed some signs of scientific literacy and could define both theories to a basic level. A lack of scientific literacy does not therefore explain the rejection of either or both theories found within this study as different individuals, who appear scientifically literate, either accept, reject, or reject parts of both theories.

4.8 Participants' views of evidence

Of the interviewees eight consider there is evidence to support either one theory or both. Two participants, Ann and Roger, consider in their view, there is little conclusive and convincing evidence for either theory, that they reject. Roger confirmed he believes instead in the "evidence" given in the DVD produced by the Creation Ministries, (Psarris, 2012), for a Biblically created universe, earth and life:

Some people think you can be a Christian and accept the theories, but that is wrong. I believe in what is in the Bible ……. design by God of the universe and life. I also have a DVD set on creation from Creation Ministries.

Some other participants, like Barbara, believe there is evidence for both theories saying:

I can see concrete examples of [biological evolution] in real life like the different colour of moths ……. [The Big Bang is] based on the fact of the research I have personally looked at, and the evidence of continuing expansion.

Alternatively, Howard sees evidence for evolution but not for the Big Bang. He explained:

I think evolution is right, but that God started it and helped it along. There is lots of evidence for evolution …… The universe has always been here. There was no Big Bang.

Peter considers there to be evidence for both theories, but also confirms that as they are theories, they may be proved wrong at a later date:

I am prepared to run with the Big Bang. I can see it is a valid possibility. It is the big theory for origins scientifically at the moment, so I will run with it till someone thinks of a better one. If this is right, then it's how God brought about creation …. I think the same [about biological evolution]. It's a theory I am prepared to run with it. I can see a role for evolution. Darker butterflies thrived more in the industrial revolution because there was more soot. They became dominant over lighter coloured butterflies. I can see that's evolution based on environment. Evolution explains a lot, but it does not explain reasons of origin.

Dean considered there is evidence to support the Big Bang but is sceptical about macro evolution. He explained:

Expansion. There had to be a start of the universe …. There is micro and macro evolution. If you say adaptation. Adaptation is part of the DNA. There is a Gnome for everyone. There is adaptation. Micro, which is adaptation can happen ……. But Macro I do not accept. There is no evidence for it. In terms of Darwin there are variations in the theory and gaps and not all scientists agree …….. Gravity is a fact. You can

measure everything about it, but Darwin is still a theory. Micro evolution can happen …. The Big Bang may be an explanation. But God started it …. On evolution I think Micro evolution, which is adaptation can happen. Evidence. But Macro I do not accept. I do not think there is evidence.

Jill considers there is evidence for both theories:

I would say thinking back billions of years there was not anything except something very very tiny that contained all the seeds of everything. To me it's a bit like a seed germinating and 'bumph' and out it comes. And the universe is still expanding …. I would say that species, animals, all kinds of life and creatures have adapted over time to their circumstances and therefore they have changed biologically over all that long period of time, adapting to their environments ……. I believe in the Big Bang because it makes intellectual sense to me that that is how the universe started, in the absence of any other ideas that make any sense to me. When the scientists said we live in an expanding universe it made even more sense ……. I think [concerning evolution] fossils.

Ella also believes there is evidence for both theories and explained that:

It [the Big Bang] has evidence like the universe is expanding …. Everything started off like this [hand gesture of something very small between her thumb and first finger] and then it kind of went bang and got bigger [hand gesture using both hands from being together to both hands arm's length wide apart]. And it's still getting bigger …. there's evidence like galaxies moving apart and the universe is getting bigger so at one point it must have been together and small.

There's evidence [for biological evolution] like fossils and the birds on the islands Charles Darwin went to. The beaks are different on each island and the tortoises are different on each island, because they have evolved differently on each island …. It's kind of how things evolved from their ancestors over millions and millions of years. So, birds evolved from dinosaurs and humans evolved from apes or something. The more they changed the better and stronger they were. And animals that didn't change colour could be seen and so could be caught easily. So, animals that changed

survived. That's survival of the fittest …. Cause there's evidence for it. Fossils and Darwin and stuff.

Josh accepts both theories and bases this on the evidence provided him during his school science lessons:

I was taught about it at school …. It's how the world and universe started. Everything was together, small and together. Then it exploded and kind of went everywhere, in all directions. Then the stars and planets formed and galaxies ……. [Biological evolution] comes from Charles Darwin. Everything that lives can trace back to one thing at the start. So, if you take us and go back and you take another animal and go back, we will have the same ancestor. Over time some types of animals die out and the ones that don't die out keep going and survive ….. There is evidence for it. Fossils. Dinosaurs.

Sue considers there to be evidence for both theories, explaining that:

I think it happened because there is evidence for it …….. I would say because it is expanding …….. I think that [biological evolution] happened too. Because there is evidence for it …. Fossils.

Findings linked to the participants' views of evidence confirmed that a majority consider there is evidence to support either theory or both, while two participants consider there is little conclusive evidence for either theory, but for differing reasons. A view of lack of evidence appears therefore to affect the participants' acceptance or rejection of the theories.

4.9 Science communication methods and disputes among scientists

Findings linked the acceptance or rejection of the two theories by some participants to science communication methods and disputes among scientists. Science communication methods include exhibitions, journals, television, radio and other media, including web based social media (Holliman, Thomas, Smidt, Scanlon and Whitelegg, 2009). Science

community-based disputes and controversies can spill over to public audiences (Holliman, Whitelegg, Scanlon, Smidt and Thomas, 2009).

Some participants, like Barbara, who rejects parts of the theory of biological evolution and accepts the Big Bang, believes scientists agree with each other on the origin of the universe and life, explaining:

> *I think they agree but then I have only watched things that support my own theory.*

Other participants, like Howard, who rejects parts of biological evolution and rejects the Big Bang, believes scientists disagree with each other on the origin of the universe and life:

> *Of course they disagree. When do scientists agree? Because they think different things. Two scientists are like two politicians. Same evidence, but completely different opinions. You see it in the papers and in the news. Scientists say one thing one week and another the next.*

Peter accepts both theories but explained scientists occasionally disagree with each other on the origin of the universe and life confirming in his view:

> *Often scientists claim too much, a current theory is assumed to be the truth and everything else is rubbish. I think you find great debate within the scientific community and a lot of pressure to perform, to publish and to claim the high ground. There are all sorts of issues within the scientific community in terms of ethics and how you claim stuff. There is turmoil in the scientific community. There is among some elements a rubbishing of Christian belief and theistic belief and yet there are a substantial number of high-quality scientists who are Christian theists. There are some in my church. High performing scientists with an integrity of Christian belief, like Lennox.*

Dean rejects some elements of both theories and explained that scientists disagree with each other:

> *They [scientists] disagree with each other. Especially on theories. The Big Bang and evolution are theories.*

Jill accepts both theories and stated scientists disagree with each other on the origin of the universe and life, stating that in her view:

> *There are scientists that disagree with other scientists because however clever people are, at the end of the day, people are still people. Scientists hold on to positions, and they do not like their positions weakened by acknowledging there are strengths in other people's positions.*

Sue accepts both theories and notes scientists sometimes disagree:

> *I think they sometimes disagree. The only way you can go forward in knowing what is true is by changing what you believe sometimes.*

Ann rejects both theories and considers scientists continuously disagree, suggesting in her view:

> *They disagree all the time. One minute you hear this opinion and the next there is exactly the opposite opinion. Look at the papers. Look at the news. They say one thing one day and another scientist says another the next.*

Roger rejects both theories and thinks scientists disagree with each other, suggesting it is similar to the change of view of a former Professor of Philosophy at Reading university:

> *They disagree, and they change their mind. With age you change your mind just like Flew.*

Ella said she accepts both theories but does not know if scientists agree or disagree with each other on the origin of the universe and life. Josh who also accepts both theories, stated that he believes scientists agree with each other on the origin of the universe and life.

Findings linked to science communication methods and disputes among scientists suggest both factors may affect the acceptance or rejection of the two theories, as poor science communication or disputes can sow doubt in science and scientific theories among the general population.

4.10 Alternative discredited theories and popular culture

Findings did appear to link the rejection of the two science theories to discredited scientific theories among some participants. The participants that were aware of discredited theories were aged between 43 and 83. The alternative theories that some participants mentioned during interviews were the Steady State theory and the Panspermia theory. The Steady State theory proposed the universe had no beginning and has no end, (Hoyle, 1948). The Panspermia theory proposed, with several variations, that the first forms of life on earth originated in other parts of the universe and after arrival on earth, via comets and meteorites, continued to evolve, (Hoyle, 1983).

Both theories are no longer considered valid in the scientific community due to the lack of evidence, and the alternative significant body of evidence for the Big Bang and biological evolution. However, both theories may still be remembered by older individuals who were taught the theories or by younger individuals who have come across the theories in non-formal learning environments. None of the participants could recall the titles or authors of old textbooks, school science books or works of fiction that may have mentioned either discredited theory. The study did not involve showing the participants examples of old textbooks as sight of these may have resulted in a false memory or false identification of a book.

Peter, Ella, Josh, Sue and Roger, aged between 18 and 53, have no recollection of either the Panspermia theory or the Steady State theory. Of these participants four accept both biological evolution and the Big Bang. Roger rejects both biological evolution and the Big Bang with no knowledge of the alternative discredited theories.

Barbara, age 45, accepts the Big Bang theory even though she is aware of the Steady State theory. However, her partial rejection of biological evolution may be linked to her knowledge of the theory of Panspermia:

> *I think that maybe the idea that evolution is wrong and that the first life on earth came from space and then evolved some more when it was on earth. It may be right. Sounds possible to me.*

Barbara confirmed that she rejects parts of the theory of biological evolution:

I am not sure about the start of evolution, because although I can see creatures evolving from a more basic form, I am not sure how the very basic form came to be on earth. I have read about that the molecules or building blocks of life are present in bits of meteors. Perhaps that the start of biological evolution was on a different planet, or somewhere else in the universe.

Howard's knowledge of the Steady State theory may have influenced his rejection of the Big Bang. Howard is 83 years old and explained:

That's [Steady State theory] the opposite to the Big Bang. The universe has always existed. There was no Big Bang.

Dean is 43 and rejects parts of both biological evolution and the Big Bang. He is aware of both the Steady State theory and Panspermia, stating that:

I heard about it [Steady State theory]. But many scientists did not put it as a candidate.

This [Panspermia theory] is another theory, but the same. It is not put up as a candidate.

However, Jill, aged 69, accepts both biological evolution and the Big Bang, even though she is aware of both the Steady State theory and Panspermia theory:

I have heard of that [Steady State theory], but I think the Big Bang happened …… There is a lot of rubbish on Sky TV about life on earth originating somewhere else and then coming here [Panspermia theory].

Ann, aged 72, said she rejects both biological evolution and the Big Bang. She considers both the Steady State theory and Panspermia theory to be possible:

Many years ago, I think I remember that [Steady State theory]. That's another theory. Might be true ……. That's [Panspermia theory] about life coming from space. Could have happened. It could have happened at any time. At the start or in the middle. I remember a book about life coming from comets and recently I remember a book about an animal in the sea coming from space. I cannot remember

if it was a squid or octopus. Then I read recently that humans could have come from space. It's all possible. You never know.

Findings concerning the Steady State theory and Panspermia theory suggest a link to some participants' rejection of the theories of the Big Bang and evolution, however this only occurred among older participants that, because of their age, knew of the discredited alternative theories. While no specific reference was made by any interviewee to popular culture films or television series, participants could not always recall where they had learnt about the two alternative theories. Participant knowledge of the alternative theories may not just have come from formal or informal education but also possibly from subliminal learning, following exposure to fiction or non-fiction, which mentions the discredited alternative theories.

4.11 Political affiliation of the participants

Findings did at first appear to show a tentative correlation between the rejection or acceptance of the two theories to the political affiliation of the participants. The number of participants that were not aligned to any political party may have been due to general voter apathy between elections and apathy to politics due to the Brexit situation in the UK in the year of the interviews, (2018). Those aligned to the Conservative party were more likely to reject the theories, while those aligned to the Labour and Liberal Democrat parties were more likely to accept the theories. Unaligned participants were more likely to reject in part or accept the theories.

However, findings linked to political affiliation may be spurious and a false correlation as no political party linked their manifestoes in any way to scientific theories and in addition the high number of non-aligned made any correlation impossible to make. Ann and Roger considered themselves Conservative Party supporters and both reject both theories. Howard is also a Conservative supporter and rejects the Big Bang and partly rejects evolution. Peter is a Liberal Democrat supporter and accepts both theories. Sue is a Labour supporter and accepts both theories. Jill, Ella and Josh are not politically aligned and all three accept both theories. Barbara is also not aligned and accepts the Big Bang and rejects

in part evolution. Dean is not aligned and rejects parts of both theories. Three participants, Peter, Dean and Jill confirmed that their political affiliation is not static but fluid from time to time, depending upon various factors and political issues of the time.

4.12 The effect of the age and gender of the participant

Gender did not affect the acceptance or rejection of the two theories with males and females equally accepting, rejecting in part or rejecting both theories. However, age did appear to affect the acceptance or rejection of both theories. Outright rejection only occurred in some participants aged 52 and above. Partial rejection only occurred in some participants 43 and above. Below this, all participants that were aged 18,19 and 31 accepted both theories. Older participants therefore showed increasing likelihood of rejection of the two theories or partial rejection. Some of the older individuals had knowledge of and were influenced by the outdated theories of Steady State and Panspermia.

Chapter 5: Findings of behaviours, including psychological patterns and opinion formation

5.1 Introduction

In this chapter the themes of participants' conscious and unconscious behaviours, including psychological patters and resulting opinions of the two scientific theories are split into nine codes, within which individual responses are compared:

- Avoidance of cognitive dissonance.
- Confirmation bias and motivated reasoning.
- The sleeper effect.
- Cognitive bargaining.
- Parallel or collateral learning.
- Intuitive/counter-intuitive views of the theories.
- Changes over the participant's lifetime in their opinions of the two theories.
- Partial or different degrees of acceptance or rejection.
- Outright acceptance or rejection.

As with influences, accounts of behaviours suggest no two life histories are the same, illustrated by the variations in responses during the interviews:

5.2 Avoidance of cognitive dissonance

Findings did note instances of avoidance of cognitive dissonance among a minority of participants. Cognitive dissonance is where inconsistent cognitions cause tension and individuals are driven to reduce it (Cooper, 2007). The actions of an individual to reduce the fear or phobia of either theory may be examples of avoidance of cognitive dissonance. Six participants showed no sign of avoidance of cognitive dissonance: Barbara, Ella, Josh, Sue, Ann and Roger.

Of the other four participants, Howard explained that he rejects the Big Bang and rejects areas of biological evolution, and his answers on his feelings about both theories appear to show signs of cognitive dissonance:

> *That [the Big Bang theory] does not sound like a nice end to everything. I don't like that idea.*
>
> *I do not feel happy about that view [biological evolution]. We do have a special place. God created us to look after the earth.*

Despite signs of potential cognitive dissonance Peter accepts both theories within his Christian beliefs:

> *Christian theology does think about the end of the universe as well. Some people think the world is going downhill anyway, so ditch the physical world problems and just concentrate on the spiritual. But the bigger, wider view and I think more valid is God is interested in us caring for creation. The rules of thermodynamics, what is declining, how did creation come out of that, because there is some energy to create and then there is decline. In theological terms there is the beauty of creation and then decline with sin and misery. There are elements of decline in the universe. There is a spiritual theological point of view that one day this world will come to an end and there will be a new heaven and earth.*

Concerning the theory of biological evolution and its implications for the place humanity is within the range of living things he commented:

> *That concerns me because it affects so many things. The status of humans is fundamental to Christian theology and Jewish theology and probably Islamic theology. So, I think if we say humans are just another animal, kill your grandmother off because she is a burden on the state. There are lots of issues of how we see life, I see life as very special. One idea looks at what was special about the first humans. In the context of evolution what do we count as the first human? Are there elements we are not told about in the Bible? When do we see humanity, that is a key moment. How do we class the first humans and what is special about them?*

Jill although showing signs of cognitive dissonance, still accepts both theories within her Christian faith, explaining that:

> *I am a bit uneasy about it [the Big Bang theory] …… It gives me a headache to think about it …… the physical world that will end …… Evolution does not deplete the human position ……. Children gradually take care of their environment, gradually take responsibility for their own actions and grow into that. At our level of evolution, we are called by God to look after the world, because we have interfered with it so much.*

Dean shows signs of cognitive dissonance concerning both theories, some elements of which he rejects, revealing that he is:

> *Not happy [with the Big Bang theory]. That will not happen because there is judgement …. [and] …. not happy [with evolution] ……. Darwinian theory cannot explain the morals or ethics of humans. I don't believe we are animals.*

Findings concerning avoidance of cognitive dissonance suggest a link between the acceptance or rejection of the two theories and cognitive dissonance among some participants. The actions of an individual to reduce the dissonance of either theory may result in either or both theories being rejected.

5.3 Confirmation bias and motivated reasoning

Findings did indicate confirmation bias and motivated reasoning among some participants, that is when an individual seeks to find only evidence that supports the individual's faith or belief. In addition, confirmation bias and motivated reasoning can also provide a feeling of happiness, as the belief it reinforces is one that makes the individual happy or content (Otto, 2016). Ella, Josh, Sue and Jill showed no signs of confirmation bias and motivated reasoning. Of the other six, Barbara appeared to show signs of confirmation bias when asked if scientists agree on the theories, revealing that:

> *I think they agree, but then I have only watched things that support my own theory. I watched documentaries on the origin of the universe that just backed up what I had*

found out previously, by Brian Cox, and also BBC Horizon. And I watched David Attenborough and Brian Cox on life and evolution.

Howard and Ann think they look for evidence that supports their existing views, as they both consider it to be part of human nature. Dean, while accepting he does the same, said he is open to other views and opinions.

Peter also believes he looks for evidence that supports his existing views, and based on his response this may, in part, be due to his faith:

Yes [I do], but I am hopefully open to evidence that challenges ……. I watch the Christmas lectures. I think they are fascinating. More recently Attenborough's Blue Planet ……. The more we learn about our world, like migrating penguins that then come back to the exact same spot, fascinating. The basic Christian view is that we are special, and we have a responsibility to care for, steward, the creation. Some Christians think the world is going to pot, so therefore make sure people know God instead, but the bigger view, the more responsible view is how we care for creation, and this care is a sign about what we think about God. He has given us the responsibility.

Roger, who also has a strong faith, admitted to only reading and watching programmes that agreed with his beliefs:

I am sure I do …. Some people think you can be a Christian and accept the theories but that is wrong. I believe in what is in the Bible …. I also have a DVD set on creation from Creation Ministries.

Findings therefore confirmed instances of confirmation bias and motivated reasoning among some participants, which may impact on their acceptance or rejection of the theories, and their willingness to consider or accept other views.

5.4 The sleeper effect

Findings did indicate a minority of participants showed signs of the sleeper effect from their interviews. The sleeper effect is when newly formed opinions appear with the passage of time to gravitate back to the opinion or belief held prior to receiving new information or evidence (Hogg and Vaughan, 2013, p. 202), or where a low credibility source of information becomes more persuasive or regains persuasiveness days or weeks later (Colman, 2009). Over time a credible source giving evidence-based information and a less credible source giving information without evidence can become as persuasive as each other, as the message survives but not the source (Hogg and Vaughan, 2013, p.203). In some instances, individuals may be given scientific facts that are believed at the point of transmission but are later rejected in favour of an alternative belief, which may have been previously held. This may be despite there being evidence for the former and no evidence for the later. Over time the sources and their credibility are forgotten but the non-scientific belief, message or viewpoint may remain.

Of the four participants that showed signs of the sleeper effect, Howard rejects in part biological evolution and rejects the Big Bang and confirmed when he had received evidence on either theory his views sometimes changed and then changed back:

> *I think that often happens. You have deeply held Christian beliefs and then you look at evidence from science or TV programmes and you change your mind for a bit. Then you change your mind back again to your traditional views.*

Dean rejects both theories in part and confirmed receiving evidence on the theories and his views changed, but then changed back, justifying this by emphasising both are theories:

> *Theories are theories. They are theories. Your view can change back.*

Ann rejects both theories and commented that switching views in this way occurs regularly for her:

> *Oh yes. Lots of times. I think one thing one day then something else the next.*

Of the participants, Peter, who accepts both theories, linked the effect to his Christian faith:

Sometimes you may consider a non-Biblical thing and then go back to the Biblical that is familiar. But there is a double interpretation. I use the Bible to see what the world looks like and I use the world to see how to understand the Bible.

Six participants, (Barbara, Jill, Ella, Josh, Sue and Roger), did not recognise receiving evidence on either theory resulting in their views changing and subsequently changing back. However, a minority of participants' findings linked to the sleeper effect suggest that newly formed opinions appear with the passage of time to gravitate back to the opinion or belief held prior to receiving new evidence, and this may impact on their acceptance or rejection of the two theories.

5.5 Cognitive bargaining

Cognitive bargaining is defined as occurring in a religious belief, where to maintain its plausibility, the religious belief undergoes a degree of deliberate modification (Hull, 1985). Of the participants half, (Barbara, Josh, Sue, Ann and Roger), did not show signs of undertaking cognitive bargaining in their views of the science theories or their beliefs. The other participants provided the following accounts:

Jill's religious beliefs have changed and today, within her Christian faith, she accepts both theories, explaining that:

Yes, because when I became a Christian I did not know about these theories. Then years after I heard about them and my views changed, and I think God used the Big Bang and evolution in his plan for us.

Ella, who is a Roman Catholic, confirmed her religious beliefs changed because of new scientific findings:

I guess so. I believe in the Big Bang and evolution. But when I was young I didn't.

Howard's religious beliefs have altered with his acceptance of aspects of biological evolution, as part of his continuing faith and belief in God, and confirmed that:

I used to believe in the creation story in Genesis. Now I think God started evolution and guided it too.

Peter's religious beliefs have altered from Biblical creation of the universe and life to accepting both biological evolution and the Big Bang within his Christian beliefs. He explained:

My childhood views were uninformed and largely unquestioning, then I came to Christian faith age 19, and I got more intellectual rigor I think by that, to challenge and discover, the need to find answers, to see how things hold together. I keep trying to find out. Galileo challenged ideas of the planets, and the church at that point was feeling threatened, even though the findings are consistent with the Christian faith.

Dean confirmed his religious beliefs have changed because of modern scientific findings but at all times continued to believe in Allah, reconfirming himself Muslim in adulthood:

In primary school years [I believed] what was written in the Qur'an. Creation …. [in secondary school] I did not believe in evolution. I believed in creation of the universe and Adam.

In adulthood Dean came into contact with both the Big Bang theory and theory of biological evolution, revealing that:

At one point I considered atheism. Atheism was appealing. Why should I not be free and enjoy my life, but I became more depressed. Then when I moved to the UK I was 35 …… I became a Muslim ……. I now think both are theories. The Big Bang may be how the universe was created. On evolution I think Micro, which is adaptation can happen. But Macro I do not accept. If science is true it will not contradict religion. And visa versa.

Findings linked to cognitive bargaining suggest that among some participants of the study their religious beliefs were deliberately modified to maintain plausibility, thereby effecting their ability to accept the theories.

5.6 Parallel or collateral learning

Findings from the study did confirm instances of parallel or collateral learning. Collateral learning in this context is the concept that learners can hold scientific thinking alongside the individual's cultural knowledge or religious belief (Jegede and Aikenhead, 2004). In the concept of collateral learning individuals can be in possession of and hold ideas of science alongside possibly conflicting personal cultural knowledge and religious belief. Parallel learning in this context involves science knowledge and cultural knowledge being compartmentalised by the learner and held separately, as opposed to secured collateral learning where science and cultural/religious knowledge are accommodated, and in some instances brought together (Jegede, 1995, and Hodson, 1998).

Josh described having two boxes in his mind that helps resolve the feeling of holding two views in parallel during science lessons, one scientific and one religious:

> *Yeh. You kind of keep them apart. The creation stories in my religion [Hindu} are different to science. Science is different. You kind of have two boxes in your mind. You put your religion in one and the science you are taught in the other. As a Hindu you kind of have boxes in your mind already because we have so many different stories of creation. Lots of different ones. They are different and they each tell a different way the universe was created. So, you already are able to have different things in your mind at the same time if you know what I mean. So, when you then start doing science it's easy. You put that in a new box in your brain. So, you have lots of things that you believe. Lots of them are not, [pause], they are not compatible with each other, but you still believe them all.*

Barbara said she did feel she held differing views in parallel during science lessons:

> *In secondary I had different beliefs all running parallel to each other at the same time.*

Howard also felt this and commented he still does:

Yes. I think I have my Christian beliefs …… I have what I know about science. Sometimes they don't agree with each other. I feel that now and I thought that when I was at school too.

Peter felt no need to resolve any feeling of contradiction and explained:

I was not pushing it to resolve the two views of the Bible and science. There was no need to decide between one or the other. I think later as adults we try and resolve stuff better. At school you are compartmentalising, not necessarily because you want to keep them apart but because you have no need to put them together. You are taught stuff in biology and different stuff in religious studies, but you don't have to resolve the two. I think that parallel learning stops mostly in adult hood. I am sure there are things we don't resolve but mainly adults try and come to a coherent view.

Dean felt the ability to hold two views was a necessity and revealed:

You had to. To get good marks. We had discussions about creation, but we did have to know evolution to get good marks.

Roger also suggested holding parallel views was necessary at school:

Yes, because you are not really being true to yourself. You believe but you have to say something else to pass the test or exam. You are playing a game to get a good mark.

Jill and Sue said they did not experience parallel learning. However, Sue became a Buddhist in her 20s and was not religious or culturally religious until that point. She did not experience any form of parallel learning at school or subsequently, possibly because she views her religion as not being concerned with creation:

It does not teach about science. Buddhism is about being a better person, helping others, doing what you can to stop suffering. That's more important. I think most Buddhists are ok with evolution and the Big Bang.

Ella felt she did not hold two parallel views during science lessons but may be an example of secured collateral learning:

We talked about God in science lessons sometimes. The teacher said God maybe started the Big Bang and evolution. I think God did do that too.

Ann said she thought she did not experience any form of parallel learning at school or subsequently. However, while at secondary school she was taught and examined on biological evolution while believing God created the universe and life:

At that time. In secondary school. I guess I believed in God, and he created everything.

This suggests that although Ann does not recognise parallel learning, it may have occurred in her school years subconsciously.

Findings suggest parallel and collateral learning occur in both universal and multiculturalist style science teaching methods. Individual parallel or collateral learning styles may influence the acceptance of both theories, as it enables two contradictory views to be held simultaneously, for example one religious and one scientific.

5.7 Intuitive/counter-intuitive views of the theories

Whether participants find the theories intuitive or counter-intuitive does appear to influence their acceptance or rejection. With the exception of Dean and Howard, those that accept the theories find them intuitive and those that reject them find them counter intuitive. Intuition is apparent knowledge and understanding without evidence or reasoning (Colman, 2009). However, it is possible that any intuitive/counter-intuitive view may have followed from an already existing acceptance or rejection of the two theories.

Barbara accepts the Big Bang theory and rejects parts of biological evolution. She finds both theories intuitive and explained:

[The Big Bang is] intuitive for me. Because it's based on the fact of the research I have personally looked at and the evidence of continuing expansion …….[Biological evolution is] intuitive for me because of the knowledge I have from school of the different stages of biological evolution that's evident in animal species, that is

imbedded in my belief. I am not sure about the start of evolution, because although I can see creatures evolving from a more basic form, I am not sure how the very basic form came to be on earth. I have read about that the molecules or building blocks of life are present in bits of meteors.

Peter accepts both theories and finds them both intuitive, revealing that in his view:

It's intuitive [the Big Bang]. People are trying to trace back to what we can find. To find evidence ……. Again [concerning biological evolution] I think people are looking for theories that fit the facts, so intuitive.

Jill also accepts both theories and considers them both intuitive, suggesting that:

Yes, it's [the Big Bang theory] intuitive. If I had never heard of the Big Bang and you had come to me and asked what about the universe, I would never say 'oh it always was'. I would say 'I believe in this Creator God and I think there was a time when he just started things off' ……. Indeed, its [biological evolution] intuitive, because it's how He did it.

Ella accepts both theories and considers them intuitive:

[The big Bang theory] intuitive or not. Intuition. Yeh, I think intuitive cause it makes sense. It's kind of obvious it happened ……. [Biological evolution] That's intuitive too cause it makes sense. You can see how faces are similar. When you see a baby monkey and its mum it's just like a human. So yeh intuitive. It makes sense.

Josh also accepts both theories and considers them both intuitive. He explained that:

It's intuitive [the Big Bang theory]. Cause it seems right ……. [biological evolution] intuitive too. Its believable.

Sue accepts both theories and she thinks they are intuitive:

It's intuitive [the Big Bang theory]. Because it seems right that over time things change ……. It's intuitive [biological evolution] for the same reason. Over time things change.

Ann rejects both theories and does not think they are intuitive, revealing that in her view:

[The Big Bang theory] It's not intuitive. It's just a theory ……. Same I think [concerning biological evolution]. It's not intuitive because it's a theory. There are lots of theories.

Roger also rejects both theories and does not think they are intuitive:

It's not intuitive [the Big Bang theory]. It did not happen ……. [biological evolution] Not intuitive either. It did not happen.

Dean rejects parts of both theories but finds one intuitive and one counter intuitive. He explained:

[The Big Bang theory] Intuitive yes. It is a theory. It makes sense ……. [Biological evolution] It is not intuitive. Something then becomes something else. It is not intuitive.

Howard does not accept the Big Bang theory that he does not think is either intuitive or counter intuitive. He rejects parts of biological evolution that he finds intuitive.

Findings linked to intuitive/counter-intuitive views of the theories suggest that the majority of participants find the theories intuitive, and this may influence their acceptance or rejection; intuitive resulting in acceptance and counter-intuitive resulting in rejection. However, it is possible that the intuitive/counter-intuitive view may have stemmed from an already existing opinion of acceptance or rejection.

5.8 Changes over the participant's lifetime in their opinions of the two theories

Interviewees changed their views of both theories at different points in their lives. Some participants also confirmed their views may change in the future, as both the Big Bang and biological evolution are scientific theories, which can be proved wrong or altered with the discovery of new scientific findings at any time.

Barbara's views and beliefs on both the scientific theories and religion changed through her life. She described that:

> *At primary school I was taught God was all powerful and could do whatever He wanted, so any Bible story was acceptable to me, including creation. But then as I grew up …… I stopped believing in God. It was that, rather than scientific teaching that changed my mind on creation ……. My beliefs in primary were different. In secondary I had different beliefs all running parallel to each other at the same time.*

Her views changed in secondary school as she was taught the theory of biological evolution but not the Big Bang:

> *We were taught about Darwin and evolution ……. I don't remember being taught anything about the origins of the universe in secondary school. My beliefs about it now are because I felt I had a gap there when I became interested in astronomy. So, as an older person I looked into that. And there were anecdotal news stories as an adult. My views on evolution had already formed at secondary school.*

Barbara explained that her views on the two science theories have changed:

> *I would say from school I had no view on the Big Bang as I didn't know much about it. I would say that's changed because I have done my own reading and research as an older person ……. I am not sure about the start of evolution because although I can see creatures evolving from a more basic form, I am not sure how the very basic form came to be on earth. I have read about that the molecules or building blocks of life are present in bits of meteors. Perhaps that the start of biological evolution was on a different planet or somewhere else in the universe.*

Howard's views on the two science theories have also changed, explaining that:

> *Perhaps my views on evolution have changed to it having happened and been started and guided by God.*

During his pre-school years Howard recalls being read and believing Biblical Genesis stories of how the world and life came about. During his primary school years he believed in Biblical creation. During his secondary school years this belief altered to include parts of the theory of biological evolution:

> *God created the universe and God played a part in evolution I think.*

During adulthood, his views continued to change:

> *I think evolution may have been started and guided by God …. I think you can believe what you like in the Church of England ……. I used to believe in the creation story in Genesis. Now I think God started evolution and guided it too …… I think the universe did not start with a Big Bang. I can remember a scientist that said it was wrong. Can't remember his name …. I think evolution is right, but that God started it and helped it along. There is lots of evidence for evolution.*

Peter's views have changed significantly since childhood when he was read Biblical stories of how the world and life came about, that he accepted and believed. At primary school he continued to believe in a Biblical origin of the universe and life, remembering that:

> *I don't recall questioning what I was taught at that stage at all. So Biblical.*

At secondary school his views altered to include biological evolution:

> *I was confirmed as Anglican during that time. I didn't at that time question evolution. The Big Bang was not taught.*

Into adulthood his views changed, and he gave this detailed explanation:

> *Lennox puts out reasons to believe as a Christian. He engages in debates with other people. He is a man of integrity and scientific rigor. You go back to Newton and gravity. Why did Newton believe in gravity? Because he believed in a rational God who makes sense, who wants to engage with humanity. In creating a rational world,*

it all makes sense. If you don't believe in a rational God, there is no reason why any scientific laws should work. A lot of the early scientists were Christians ……. To use Darwin's evolution to exclude the Christian God is not a true reflection of what Darwin believed. The gap between God and science is more recent. As Christians we believe God existed before the world and there must have been some way how it all came to be. How did this table get to be here? [Peter taps the table three times]. *We trace it back through time and expansion of the universe and the rest. I have no problem if God chose to put the world into being through the Big Bang. And evolution likewise. There may be issues like what counted as the first humans ……. [the Bible] is not trying to tell us everything. It's not a scientific handbook. There may well have been bits not included in the Bible story about how humans came to be.*

I am prepared to run with the Big Bang. I can see it is a valid possibility. It is the big theory for origins scientifically at the moment, so I will run with it till someone thinks of a better one. If this is right, then it's how God brought about creation.

His views on biological evolution have also changed with time:

It's a theory I am prepared to run with it. I can see a role for evolution. Darker butterflies thrived more in the industrial revolution because there was more soot. They became dominant over lighter coloured butterflies. I can see that's evolution based on environment. Evolution explains a lot, but it does not explain reasons of origin.

Dean's views on the theories have changed significantly since childhood:

I now think both are theories. The Big Bang may be how the universe was created. On evolution I think Micro, which is adaptation can happen. But Macro I do not accept. If science is true, it will not contradict religion. And visa versa.

As a pre-school child he recalls believing in the story of creation of the universe and life given in the Qur'an. In primary school he recalls continuing in this belief and in secondary school he rejected evolution and the Big Bang:

I believed in creation of the universe and Adam.

Then at university and adulthood Dean's views on the two theories changed and developed to his current position of only accepting some elements of both and rejecting others:

> *The Big Bang may be an explanation. But God started it.*
>
> *On evolution I think Micro evolution, which is adaptation can happen. Evidence. But Macro I do not accept. I do not think there is evidence.*

Jill's views have changed significantly over her lifetime and as both the Big Bang and biological evolution are theories, she confirms that her views may change if the theories are proved wrong in the future. Jill's views as a child were influenced by her family, friends and schools as she described:

> *My father was an absolute atheist and he would not have anything to do with church ….. My mum was, like the majority of the population, with some vague idea that there probably is a God, but she had never been to church so she had no background in religion, but she was not against things like my father was. So, I started going to the church with my friend and then two years later I asked to be baptised, much to my father's displeasure and horror. He would not speak to me, it was horrible. Then I became a member of the Methodist church and that's how things progressed from there …... None of my siblings or family was religious or had a faith ……. My parents and my siblings did not even think about evolution or the Big Bang. I am the only person in my family that has passed any exam at all, so they are not thinkers.*

At pre-school age she recalls no beliefs in religion or views of science:

> *Nothing. I did not come across anything religious or thinking about things until I was at school.*

Her school years were transformative years, revealing that:

> *It was so different to home life. I remember I loved the hymns at school. I am sure at that age I did not understand them. I was a very early reader. I was intellectually bright, but I did not have any encouragement so to be. But I was a really fluent reader at 5 to 6, I could just pick it up. It was so different. Secure.*

However, she recalls nothing was taught at primary school with regard to the origins of the universe or life. This resulted, at that age, in no beliefs or views with regard to either scientific theory or religion. In secondary school science lessons did not touch on either the origin of the universe or life:

> *Origin of the universe never came up. We didn't do evolution.*

As a result, during her secondary school years she had no view on either the Big Bang or biological evolution:

> *I never thought about it. I was 14 when I started going to church, but that was New Testament and at school it did not come up as a topic.*

Jill started to encounter scientific theories of the origin of the universe and life after university:

> *It was not until I was at university that I had any experience of discussing religious things. Oh my god this was marvellous. I loved the seminars at university. I felt oh my god. I read Genesis was not written first, it was written during the Babylonian exile. Looking back now, I never believed in the seven days of creation. I looked on it as a bit of poetry ……. At 24 I met my husband. He had done a degree in physics, and he had taught science at a comprehensive school ……. I didn't know about them [the Big Bang and biological evolution] at school and at university and after that you learn things. I found out about them through reading or discussions or television documentaries.*

Jill's current views on the two theories are ones of full acceptance of both theories within her personal Christian belief. She explained her position:

> *I accept them [the Big Bang and biological evolution]. I see God standing outside of time and there was a point when our Creator God set things in motion. I don't like the Genesis six-day creation story because I don't think God is in a hurry like we are ……. This is a world in process and in progress. We are so egotistical, we say we are top of the tree. Who knows what phases comes next. There will be more changes, biological and whatever in the course of time ……. It makes intellectual sense to me that that is*

how the universe started in the absence of any other ideas that make any sense to me. When the scientists said we live in an expanding universe it made even more sense. It makes logical sense because God's chief nature is creation ……. Things evolve slowly and gently.

Ella's views have changed significantly since childhood, revealing that:

I believe in the Big Bang and evolution. But when I was young I didn't.

Growing up during her pre-school years and primary school years Ella believed in Biblical creation of the universe and life:

I guess I believed what I was told. God created everything.

Then at secondary school Ella was introduced to both the Big Bang theory and theory of biological evolution and told they could be accepted within her Catholic faith.

During her secondary school years, she described what she believes were the origins of the universe and humanity:

I guess what was told us by the teachers. So, we evolved. And the universe started with the Big Bang ……. We talked about God in science lessons sometimes. The teacher said God maybe started the Big Bang and evolution. I think God did do that too.

In adulthood Ella has no difficulty accepting both scientific theories within her faith. She explained:

I think the Pope said they happened. I think it's ok to believe in them if you are a Catholic ……. It happened [the Big Bang]. It has evidence like the universe is expanding ……. I agree with [biological evolution] ……. There's evidence like fossils and the birds on the islands Charles Darwin went to. The beaks are different on each island and the tortoises are different on each island, because they have evolved differently on each island.

Ella summarised her reasons why her views have changed to accepting both theories:

Cause it happened and there's evidence like galaxies moving apart, and the universe is getting bigger so at one point it must have been together and small ……. there's evidence for it. Fossils and Darwin and stuff.

Josh's views of his religion have remained unchanged through his life while his view on the two science theories changed in secondary school having been introduced to them at primary school. He described:

[At primary school] I think I believed the stories I had been told by my parents and at the Temple ……. [At secondary school] I guess what we did in science. The universe came from the Big Bang, and we evolved.

This change may have coincided with his ability to knowingly hold parallel views during his secondary school years:

You kind of keep them apart. The creation stories in my religion are different to science. Science is different. You kind of have two boxes in your mind. You put your religion in one and the science you are taught in the other. As a Hindu you kind of have boxes in your mind already because we have so many different stories of creation …… So, you already are able to have different things in your mind at the same time if you know what I mean. So, when you then start doing science it's easy. You put that in a new box in your brain. So, you have lots of things that you believe. Lots of them are not, [pause], they are not compatible with each other, but you still believe them all ……. I didn't know about them [the two theories] when I was young. Then I got taught about them at school. So, what I think about them has changed.

Sue's views of both science and religion have change in her lifetime. Sue grew up in a secular household that she did not consider culturally religious. At secondary school she was introduced to the theory of biological evolution. The Big Bang theory was not part of the science curriculum. Having left school Sue undertook private study into the origins of the universe including the Big Bang theory and in the same period became an agnostic Buddhist. Today, as well as being Buddhist she accepts both scientific theories. She described how during this period her views changed:

Quite a bit. I have always been interested in religion and thinking. Then a few years ago I started looking at Buddhism ……. I think quite a bit too. I only really started to be interested in it [science] when I was older. I think both [theories] are true ……. It [Buddhism] does not teach about science. Buddhism is about being a better person, helping others, doing what you can to stop suffering ……. I think most Buddhists are ok with evolution and the Big Bang. I think they [the theories] are ok too.

Ann's views of both science and religion change regularly:

I think one thing one day then something else the next.

During her school years Ann believed God created the universe and life. Today Ann does not follow a religion and is unconvinced about scientific theories:

I am very sceptical of them.

Roger's views of both the scientific theories and religion have never changed and have been constant throughout his life. He explained that:

I am an evangelical Christian …. I grew up with my parents and brother. We are all Christian …. God created everything as in the Bible .... God created the universe and all things just like it says in the Bible …. Some people think you can be a Christian and accept the theories but that is wrong. I believe in what is in the Bible …. You should believe in one or the other. If you are a Christian you should believe in the Bible and creation.

Findings confirm that most participants had changed their views of both theories at various points in their lives, sometimes significantly. Some participants also suggested their views may change in the future as both the Big Bang and biological evolution are scientific theories, that can be proved wrong or altered due to new scientific findings at any time.

5.9 Partial or different degrees of acceptance or rejection

It was noted from the interviews that 50% of participants accepted both theories, (Peter, Jill, Ella, Josh and Sue), and 50% of participants rejected one or both theories in whole, (Ann and Roger), or in part, rejecting a specific element of a theory, (Barbara, Howard and Dean).

Barbara confirmed she rejected parts of the theory of biological evolution, sharing a similar view to Hoyle (1983):

> *I am not sure about the start of evolution because, although I can see creatures evolving from a more basic form, I am not sure how the very basic form came to be on earth. I have read about that the molecules or building blocks of life are present in bits of meteors. Perhaps that the start of biological evolution was on a different planet or somewhere else in the universe. I think I agree with evolution in part ……. I think that [Panspermia] may be the idea that evolution is wrong and that the first life on earth came from space and then evolved some more when it was on earth. It may be right. Sounds possible to me.*

Howard also rejected elements of biological evolution, explaining that:

> *Because God played a part in evolution. He started it and looked after it ……. I think evolution is right, but that God started it and helped it along. There is lots of evidence for evolution.*

Dean rejects elements of both theories:

> *In terms of logical theory there was nothing and then the universe came and expanding. It makes sense. But it's a theory and it can change obviously. There are some scientists that reject it. To be honest it's a theory. It is in the Qur'an ……. Micro evolution, which is adaptation can happen. But Macro evolution I do not accept. I believe Allah created Adam by His hands ……. The Big Bang may be an explanation. But God started it ……. On evolution I think Micro evolution, which is adaptation can happen. Evidence. But Macro I do not accept. I do not think there is evidence.*

Findings linked to partial or different degrees and levels of acceptance or rejection of the science theories confirmed that some participants do have partial or differing degrees of

rejection, suggesting the complex nature of views on the theories, which are often not straightforward.

5.10 Outright acceptance or rejection

Of those participants that stated their outright acceptance or rejection of one or both theories, Barbara accepts outright the Big Bang theory. She explained her reasoning:

> *Because I don't believe in creation by God and because of my own personal research on the topic …… I suppose because right now there is real life evidence that the universe is continuing to expand so that backs it up …… I would say because of my own scientific reading and things that I have watched, that back up that theory.*

Peter accepts both theories outright, revealing that:

> *It does not put me at odds with my Christian beliefs. God could have started both the Big Bang and evolution. I am prepared to work with scientific theories and with the Bible ……. Again, I am willing to work with scientific theories. They are theories that can be proved wrong at any point in the future. We can see evidence of evolution …… I am prepared to run with the Big Bang. I can see it is a valid possibility. It is the big theory for origins, scientifically at the moment, so I will run with it till someone thinks of a better one. If this is right, then it's how God brought about creation …… I think the same [about biological evolution]. It's a theory I am prepared to run with it. I can see a role for evolution ……. Evolution explains a lot, but it does not explain reasons of origin.*

Jill also accepts both theories. She explained:

> *I accept them [the Big Bang and biological evolution]. I see God standing outside of time and there was a point when our Creator God set things in motion ……. Who knows what phases comes next. There will be more changes, biological and whatever in the course of time …… I believe in the Big Bang because it makes intellectual sense to me that that is how the universe started in the absence of any other ideas that make any sense to me. When the scientists said we live in an expanding universe*

it made even more sense. It makes logical sense because God's chief nature is creation ……. Things evolve slowly and gently and also I think it is an act of a merciful God, that shows us things have evolved and so people should have a bit of faith in the process.

Ella accepts both theories outright, confirming that:

I agree with it [the Big Bang theory]. It happened. It has evidence like the universe is expanding …… Yeh I agree with that [biological evolution] too. There's evidence like fossils and the birds on the islands Charles Darwin went to. The beaks are different on each island and the tortoises are different on each island, because they have evolved differently on each island ….. [The Big Bang] happened and there's evidence like galaxies moving apart and the universe is getting bigger, so at one point it must have been together and small.

Josh also accepts both theories. In his view:

It's true [the Big Bang]. I was taught about it at school …. That's true too [biological evolution] .... The creation stories in my religion are different to science. Science is different. You kind of have two boxes in your mind ……. There is no problem in being a Hindu and accepting science. I am a Hindu and I also believe in science …. I was taught [in school] about it [the Big Bang]. There is evidence that it happened. The universe is getting bigger …. I was taught about it [biological evolution] in school. There is evidence for it. Fossils. Dinosaurs. How animals evolved. It's true.

Sue accepts both theories outright. She explained her reasoning:

Yes, I think it [the Big Bang] happened because there is evidence for it …. I would say because it is expanding.

I think that [biological evolution] happened too. Because there is evidence for it …. Fossils I think …. I think most Buddhists are ok with evolution and the Big Bang. I think they are ok too …. There is no evidence against it. It has evidence for it …. There is no real evidence against it [biological evolution] but there is evidence for it.

Ann rejects both theories. In her view:

It [the Big Bang] all sounds a bit farfetched to me. It's a bit like God. What made God? What made the thing that made God? It's the same with the universe. What made the Big Bang? What made the thing that made the Big Bang? It's all ideas and theories. No one really knows.

It's all guesswork …. [Biological evolution] …. For the same reason. It's all too far-fetched for me to accept. There are too many gaps. I saw a book the other day that said humans may have come from space. If they did then they did not evolve. They arrived. So, no. It's just another idea. All guesswork …… Because it's just another theory. I am very sceptical of science theories.

Roger also rejects both theories outright, explaining that:

It's [the Big Bang] never been proved. It's a theory not a fact …. Again, because it [biological evolution] has not been proved. It's just a theory …. Some people think you can be a Christian and accept the theories, but that is wrong. I believe in what is in the Bible.

Howard rejects the Big Bang theory:

Because the universe has always been here. There was no Big Bang ……. I think the universe did not start with a Big Bang. I can remember a scientist that said it was wrong. Can't remember his name.

Findings of outright acceptance or rejection of the science theories confirmed that some participants held categoric views of either or both theories resulting in acceptance or rejection. However, it was found that other participants accept one and reject the other, in whole or in part. Both theories validity is therefore considered independently of each other by participants. Some participants' views on both theories changed with new or altered evidence and personal review.

Chapter 6: Discussion

6.1 Introduction

Mertens (2015) confirms the essential properties of validity and reliability in research and its systematic inquiry, ensuring that any claims should be made based on sufficient data to support them, and any processes of analysis and interpretation should be made visible. With this in mind, the thesis discussion of the study findings will adhere rigorously to the study data, which is transparently analysed and interpreted. The relevance and importance of the data will be confirmed, leading to a theory of opinion formation specific to the two scientific theories, which helps explain their acceptance or rejection, underpinned by the study data.

6.2 Themes arising from the data analysis

The study data indicate that each participant reports being affected by single or multiple factors that result in them accepting or rejecting either or both of the two scientific theories. The data suggest a model of opinion formation that recognises the influence of deep and broad factors in the rejection or acceptance of scientific theories, similar to that proposed by Vygotsky (1978). For example, Peter, a practicing Christian, accepts both theories and Ann, who thinks religions are “a load of rubbish” rejects both. These findings run counter to the view that religion is to blame for the rejection of some scientific theories, including the Big Bang and biological evolution, that is found in Dawkins (2008), Verhey (2005), Moore (2007), Moore and Cotner (2009), Moore et al (2011) and Wiles and Alters (2011). Instead, by using qualitative life history research, single and multiple factors other than or including religion can be identified, where more than one factor and possibly several can act together to produce an effect (Punch, 2005). The study findings are in alignment with a number of scholars who believe that individuals’ views are formed and often reformed over time from early childhood, that was discussed in the introduction and literature review (Turner and Oakes 1986, Tajfel 1982, Kegan 1982, Fowler 1982, Glover 2014, Kim 2022, Chacoma and Zanette 2015, Medo, Mariani and Liyuan 2021, Chan,

Duivenvoorden, Flache and Mandjes 2024). The rich process of opinion formation in most cases cannot be reduced to a 'one-off' decision to accept or reject the theories. Instead, it is a process that continues through all ages, taking shape from all aspects of life, from birth to old age, resulting in a developmental process of stages in opinion. The process of meaning-making to form perspectives and opinion formation is therefore a lifelong activity and is often the subject of personal reassessment and revaluation, resulting in different opinions held within one lifetime. This is shown by the differing influences, behaviours and opinions that each individual detailed in their life history interviews, confirming no two participants' reasoning was the same, illustrated in the vignettes given in chapter 4. The influences and behaviours result in opinions that can alter in different directions throughout life. These influences and behaviours will now be discussed.

6.2.1 Influences

Religion, culture and family

The study data show that religious belief is not an automatic cause or indicator of an individual's rejection or acceptance of the two scientific theories. In some participants, for example Jill and Peter, religious belief is in fact a direct reason why the interviewee accepts both theories, as the theories can help explain their God's methods of creation. For other interviewees, for example Roger, religious belief has contributed to their rejection of both theories, as he believes in a literal Biblical creation. Ann has no religious affiliation and yet rejects both theories and Barbara is an atheist who rejects areas of evolutionary theory.

The study data given by Dean, who is a Sunni Muslim, confirms that in Islam there are Qur'an verses that can be interpreted as supporting both the Big Bang and biological evolution. Allah is described as the "expander" of the universe (Qur'an, 51:47), who created life "in stages" (71:14). However, other verses of the Qur'an indicate an instantly created Universe and unevolved created humanity beginning with Adam (2:29, 3:190, 7:54, 10:3, 17:61, 17:70). Among Muslim communities there may therefore be a variation between acceptance and rejection of both the Big Bang and biological evolution (Pew, 2009).

The study found similarity with examples of scientists who have a religious belief that accepted biological evolution or the Big Bang, for example Lemaitre (1958), and scientists that rejected religious beliefs and also rejected the Big Bang and rejected aspects of biological evolution, for example Hoyle (1948 and 1983). The study findings support the view that religion may not be the enemy of science and scientific theories.

The study data shows culture does not by itself appear to impact on the acceptance or rejection of either theory, unless both the individual's culture and religion are inextricably linked, in which case they may affect the acceptance or rejection of either or both theories. Family appears to have no consistent impact on acceptance or rejection, for example Jill who holds the opposite view to her parents and Roger who holds the same view as his parents. While in early years, especially pre-school and primary school years, family beliefs may influence childhood views, no participant gave their family's beliefs or views as the reason for their rejection or acceptance of either scientific theory in adulthood.

Education teaching methods and feelings of isolation or inclusion

Study data did not provide a conclusive link between the acceptance or rejection of the two science theories and universal or multicultural science style teaching methods. Those participants that attended formats similar to multicultural science education lessons were less likely to totally reject both scientific theories, but as rejection of either theory or rejection of parts of either theory occurred with recipients of both teaching methods, neither method can be suggested more beneficial in ensuring acceptance of either theory by students. The study data indicate that some participants who attended lessons similar to a multicultural science education style gave a positive appraisal of both scientific theories, for example Dean and Ella. This may be because areas of the human brain pay close attention to an explanation using historical narrative, which may increase understanding (Bower and Clark, 1969) as the use of "story" backs up learning of pure theory (Green 2004).

The study data did indicate that feelings of religious and cultural isolation among participants occurred in universal science education teaching styles, for example, in the accounts given by both Barbara and Roger. There were no instances of religious or cultural

isolation among participants who had attended multicultural style science lessons. Religious or cultural isolation during education are feelings of isolation in lessons or in the educational establishment, due to a student's religion or culture (Biggs and Tang, 2011) and can result in educational underachievement of groups or individuals (Kiwan, 2012). Multicultural style science education may help students avoid isolation of this type. Cultural or religious isolation may influence the rejection of the two science theories as it can reduce or stop involvement in the learning process, for example in the accounts given by both Roger and Barbara.

The study data of Roger and Barbara suggest support for Biggs and Tang's (2011) recommendation that teachers plan against any form of cultural or religious isolation of learners, as any feelings of isolation can result in educational underachievement (Kiwan, 2012). To encourage inclusion and participation the pedagogy of multicultural science education suggests that students are given a narrative process and stories within science that allow open discussion of alternative views. Cohen et al (2010) suggest lesson content needs to draw on a group's diversity of cultures and to fairly represent cultures, thereby reducing feelings of isolation. Bruner (2004) also recommends using a narrative process in science teaching. There should therefore be effective learning support in the subject areas of the Big Bang and biological evolution, so that teachers and institution management have the flexibility and background knowledge of cultures and religions to support students in these scientific areas. Teachers can successfully construct the learning opportunity by building upon learners' cultural and religious backgrounds (Kyriacou, 2012; Bowl, 2012), thereby reducing or eliminating feelings of cultural or religious isolation by using cooperative learning (Petty, 2009). Multiculturalist science education teaching styles may be able to avoid cultural isolation of pupils during culturally and religiously sensitive units of science courses involving the origins of life and the universe. The study findings of Roger and Barbara indicate that cultural and religious isolation in learning may be a contributing factor in the non-acceptance or rejection of the Big Bang and biological evolution in lifelong leaning by some individuals, as isolation results in learners reducing participation, and potentially rejecting science learning. However, it is possible to use inclusive teaching methods and use historical narrative in science lessons without completely changing teaching styles to multicultural science education.

Level of education and scientific literacy

Study data linked to the level of formal education of the participants indicate an inconclusive link to acceptance or rejection of the two theories. The individuals that rejected both theories did not attend to tertiary level education and stopped at secondary level. In addition, within their secondary education they did not study science after 16. However, three participants that did not attend tertiary level accepted both theories in full. Further, the five that did attend university provided an inconclusive mixture of acceptance and rejection.

Within the study data there appeared to be no significant signs of scientific illiteracy, where scientific literacy is defined as the knowledge of concepts and theories of science (OECD, 2015). Despite no participant appearing scientifically illiterate, the study contained participants that both rejected and accepted the theories. All participants were able to define and describe both the Big Bang theory and biological evolution to a basic level. Study data indicated that a lack of scientific literacy does not explain the rejection of either or both theories found within this study as all participants, who all showed signs of scientific literacy, either accept, reject, or rejected parts of both theories. For example, Josh who accepts both theories, Roger who rejects both and Dean who rejects parts of both theories. There is no consistency among scientifically literate individuals. However, the two participants that did not accept either theory, Ann and Roger, also stated that there was no conclusive evidence to prove either theory. These two participants could define the theories but had lower levels of acceptance of the evidence for the theories. As being able to evaluate and comprehend evidence is a key element of scientific literacy, the evaluation of these two participants being scientifically literate can be questioned. It is also noted that both attended education to secondary and not tertiary level and within secondary education stopped science subjects at 16 not 18. This suggests that studying science to a less advanced level and possessing fewer tertiary level analytical skills may contribute to rejection of both theories. In the wider population beyond this study the 2004 Gallup poll confirmed 35% of respondence said that biological evolution was not supported by evidence, which indicates levels of scientific illiteracy. 25% of those surveyed said they did

not know enough about biological evolution to answer questions about it (Ra, 2016). If one quarter of the population is scientifically illiterate on the subject this may contribute to the rejection of the two theories.

However, scientific literacy cannot be measured by the acceptance of both theories. As could be seen from the literature review, several examples can be given of scientists and scientifically literate academics who at one stage rejected either or both theories at a point in their lifetime in whole or in part. Examples of this are Hoyle (1983, 1990, 1994 and Singh, 2004), Einstein (1917), Hawkins who rejected the Big Bang until undertaking his PhD, (2013), Lennox who rejects both theories without the addition of the Christian God actively participating and altering both while in progress, (2009, 2011a and 2011b), and Flew who in later life rejected his past atheism and argued for an intelligently designed and periodically intelligently altered version of the Big Bang and biological evolution, that did not conform to the scientific theories, arguing that he believed in "the principle of following the argument wherever it may lead me" (Flew and Varghese, 2007, p. 56).

Alternative theories and popular culture

The study data has shown that among older participants the discredited Steady State and Panspermia theories still influence the acceptance and rejection of the two science theories. The study participants that are aware of the discredited theories are aged between 43 and 83. None of the participants could recall the titles or authors of old textbooks, school science books or fictional works that may have mentioned either discredited theory. Both the Steady State and Panspermia theories are no longer considered valid in the scientific community due to the lack of evidence, and the alternative significant body of evidence for the Big Bang and biological evolution. However, both theories are still remembered by some older individuals, for example Howard in the study. The study has confirmed that the lingering impact of the Steady State theory still occurs today as those in their 50s and over may still recall being taught the Steady State theory at school and at university. Some of these individuals may still consider it valid and may inform younger generations of this in social settings, as was the case in the researcher's own childhood, being informed about the theory by his parent.

Study participants' views on the theories were often formed in their teenage years, for example Barbara, Howard, Peter, Dean, Jill, Ella and Ann, including by reading schoolbooks or encyclopaedias. The Collins Concise Encyclopaedia (Mallory, 1984), as late as 1984, continued to give equal credence to the Steady State theory and the Big Bang theory. Although study participants over the age of 43 remember the Steady State theory from schoolbooks and encyclopaedias, none could recall the authors or book titles.

This study data suggests younger participants, for example Josh and Ella, both under 20, do indeed have a greater acceptance of both theories than older participants. While the study data indicates gender does not impact the acceptance or rejection of the two scientific theories, age does appear to have an effect, often linked to older participants' knowledge of the Steady State theory and Panspermia theory, for example Ann, aged 72, and Roger, aged 52, who both recall learning and reading about the theories. Some study participants over the age of 43, for example Dean, are aware of the Panspermia theory, proposed by Hoyle (1983) that is based on the difficulties of explaining the origin and existence of DNA and the first living things that derive from non-living building blocks.

While no specific reference was made by any interviewee to popular culture films or television series, participants could not always recall where they had learnt about alternative theories and did not discount sources of popular fiction. Participant knowledge of the alternative theories may not just have come from formal or informal education but also from subliminal learning following exposure to fiction or non-fiction, book, films, television or social media, which mentions the discredited alternative theories.

Scientific disputes, poor science communication and views of evidence

The study data has shown disputes among scientists and poor science communication methods can affect acceptance and increase rejection of the two theories as both factors can sow doubt among lifelong learners. Howard, Peter, Dean, Jill, Sue, Ann and Roger all gave examples of how disputes among scientists have detrimentally affected their opinion about scientific theories. Science community-based disputes and controversies can spill over to public audiences, becoming a public dispute among scientists and the general population (Holliman, Whitelegg, Scanlon, Smidt and Thomas, 2009). Both the Big Bang theory and

theory of biological evolution have significant external dimensions where the theories are science-based, but where there are cultural and religious aspects in human society that can have a powerful influence on the acceptance or rejection of the theories among individuals when disputes among scientists occur. Sherwood (2011) confirms science controversies seem to pit experts against one another. The examples of science communication that have resulted in the Big Bang theory still being contested involve both the overall encompassing umbrella of the theory being disputed and also the crucial small elements of sub-theories being disputed that hold the over-arching theory together (Spitzer, 2010).

Non-peer reviewed announcement, books, blogs, pamphlets, television programmes and other media outlets appear in this study to be a source of controversies that have an effect of the rejection of scientific theories. Among the participants of the study, Roger used the un-peer reviewed Psarris (2012) Astronomy DVD series as evidence for his rejection of the Big Bang theory. The study data therefore found that some participants had based their views of the two theories on non-peer reviewed publications. Participants did not necessarily access resources with a strong evidence base to form their opinion. Study data of the participants' views of evidence confirmed that a majority consider there is evidence to support either theory or both, and two participants considers there is less evidence for either theory, but for differing reasons. A view of lack of evidence does therefore affect the participants' acceptance or rejection of the theories.

Age, gender and politics

Study data linked to the effect of the age and gender of the participant confirmed that while gender did not impact the acceptance or rejection, age did appear to affect the acceptance or rejection of both theories, linked to older participants' knowledge of the Steady State and Panspermia theories.

Study data appears at first glance to link the rejection or acceptance of the two theories to the current political views of the participants. Conservative party voters, Roger, Ann and Howard appear in the study more likely to reject in part or totally either or both theories. However, this may be due to other factors. The higher number of participants that were not

aligned to any political party may be due to general voter apathy between elections and apathy to politics due to the Brexit situation in the UK in the year of interviews, 2018. Those aligned to the Conservative party were seemingly more likely to reject the theories, while those aligned to the Labour and Liberal Democrat parties, Sue and Peter, were more likely to accept the theories. Unaligned participants were more likely to accept in part or accept the theories.

However, the three Conservative voters were all 52 or over, and two of the Conservative voters had heard of the Steady State theory or theory of Panspermia. In addition, The Conservative party's manifesto (2019 and 2024) did not mention the teaching of the Big Bang theory or Theory of biological evolution in school nor any aspect of either theory. The possible link of rejection of some scientific theories to UK politics, (as opposed to, for example in America, to United States politics), is therefore a false correlation.

6.2.2 Behaviours

Cognitive dissonance

The study data confirms that the avoidance of cognitive dissonance is linked to the acceptance or rejection of the two scientific theories among some participants. Cognitive dissonance, where inconsistent cognitions cause tension and a drive to reduce it (Cooper, 2007) was noted in a minority of participants. While six of the participants showed no signs of avoidance of cognitive dissonance, both Dean and Howard showed signs concerning the implications of both theories, Peter showed signs concerning the implications of biological evolution and Jill showed signs concerning the Big Bang theory. The actions of an individual to reduce the fear of either theory may result in either or both theories being rejected by the participant and are examples of avoidance of cognitive dissonance. The literature review confirmed the "dark cold death" of the Universe was a direct element in Hoyle (1960) rejecting the Big Bang and expanding universe, and this study found the same among some participants, (Ann and Roger). There are psycho-social reasons to either accept or reject both theories. For example, the Big Bang gives a point of creation in time for those that

believe in a deity. Alternatively, the Steady State theory avoids the "dark cold death" of the Universe that can cause concern or fear.

The study data of Howard, Peter and Dean confirms that fear exists among some participants for the implications of the theory of biological evolution, as well as the Big Bang. For example, a deeply held religious view of the unique status of humanity, as God created over-seer of all other life on earth, is challenged by the concept of humanity given in the theory of biological evolution. Individuals that hold a religious view of humanity's special status on earth and in the universe may have a fear of the implications of biological evolution upon the status of humanity, and therefore upon their faith.

Confirmation bias and motivated reasoning

The responses of Barbara, Howard, Peter, Dean, Ann and Roger confirmed that confirmation bias or motivated reasoning among some participants may impact the acceptance or rejection of the theories. Confirmation bias or motivated reasoning, where individuals seek to find only evidence that supports the individual's view can lead to a feeling of happiness as the view it reinforces is one that makes the individual content (Otto, 2016). This finding is similar to that found in the literature review where retired neurosurgeon, U.S. Presidential candidate and Seventh Day Adventist Ben Carson is an example, as in accordance with his faith, he dismisses both the Big Bang and biological evolution despite being fully aware of the considerable scientific evidence for both theories and instead takes a fundamentalist Biblical standpoint on the creation of the universe and life, because of his faith (Otto 2016).

Sleeper effect

Among the study participants, Howard, Peter, Dean and Ann confirmed that newly formed opinions appear with the passage of time to gravitate back to the opinion or belief held prior to receiving new scientific evidence, and this may impact on their acceptance or rejection of the two theories, as it indicates the "sleeper effect" (Hogg and Vaughan, 2013), where a low credibility source of information can become more persuasive, or regain persuasiveness days or weeks later (Colman, 2009). Over time, a credible source giving

evidence-based information and a less credible source giving information without evidence can become as persuasive as each other, as the message survives but not the source (Hogg and Vaughan, 2013). In some instances, for example Howard, Peter, Dean and Ann, individuals may be given scientific facts that are accepted at the point of transmission but are later rejected in favour of an alternative view that may have been previously held, despite there being evidence for the former and no evidence for the later. Over time the sources and their credibility are forgotten but the non-scientific belief, message or viewpoint remains.

Cognitive bargaining

The study data show that religious beliefs of some participants, for example Howard, Peter, Dean, Jill and Ella, were noted to have been deliberately modified by the individual in order to maintain the religious belief's plausibility, thereby increasing the acceptance of the two theories. These study findings indicate cognitive bargaining has occurred among these participants, where in order to maintain plausibility, a religious belief undergoes a degree of deliberate modification (Hull, 1985). Cognitive bargaining can occur in an organised belief system or in an individual's personal belief. In the 20th century, the most significant example of cognitive bargaining within an organised religion was the acceptance of the Big Bang and expanding universe by Pope Pius XII in 1951 (Farrell, 2010). Data from the study indicated all participants, with the exception of Roger, changed their views of both scientific theories, as well as their religious views, at various ages, indicating significant levels of fluidity of views are possible among some individuals. Participants also confirmed their views may change in the future, as both the Big Bang and biological evolution are theories that can be proved wrong or altered in the event of new scientific findings. The study data shows that participants, for example Barbara and Dean, can have partial or differing degrees of acceptance and rejection, confirming the complex nature of views on the theories that are not straightforward and cannot be answered with simplistic affirmative or negative answers. However, the majority of participants hold categoric views of either or both theories resulting in acceptance or rejection. Some participants also accept one of the

scientific theories and reject the other, in whole or in part, for example Howard. Both theories are therefore often considered independently by participants.

Parallel/collateral learning

The stories of Howard, Ann, Josh, Barbara, Peter, Dean, Roger and Ella indicated that parallel learning and secured collateral learning occurred in both universal and multicultural style science teaching methods and that individual parallel or collateral learning assisted in the acceptance of both theories. Collateral learning, experienced by Howard and Ann suggests learners can hold scientific thinking alongside possibly conflicting personal religious belief and cultural knowledge, as suggested by Jegede and Aikenhead (2004). Parallel learning, experienced by Josh, Barbara, Peter, Dean and Roger, involves science knowledge and religious or cultural knowledge being compartmentalised by the learner and held separately, as opposed to secured collateral learning, experienced by Ella, where science and religious or cultural knowledge are accommodated, and in some instances brought together (Jegede, 1995 and Hodson, 1998). Model-dependent realism can also be used as an approach by learners that can hold two or more compartmentalised views, as there may be different ways in which one could model the same physical situation or event, the student using whichever model is most convenient or acceptable, as suggested by Hawking and Mlodinow (2010). Collateral and parallel learning, as experienced by some participants in this study, can combat learner's feelings of isolation because of beliefs or culture, thereby avoiding learners refusing to engage in science learning. However, not all individuals find it possible to undertake, consciously or subconsciously, this type of learning method.

Intuition

The study data suggests that intuitive or counter-intuitive views of each theory may influence their acceptance or rejection. With the exception of Dean and Howard, those that accept the theories find them intuitive and those that reject them find them counter intuitive. However, it is possible that the intuitive/counter-intuitive view followed from an already existing acceptance or rejection. Some participants in their responses confused

intuition/counter intuition with the presence of or lack of scientific evidence and therefore not all the participants' views of intuition are valid, (for example Barbara), as intuition is apparent knowledge and understanding without evidence or reasoning (Colman, 2009).

6.2.3 Rejection or acceptance

In the study outright rejection only occurred in some participants aged 52 and above, for example Ann and Roger. Partial acceptance only occurred in some participants 43 and above, for example Dean, Howard and Barbara. Below this age all participants accepted both theories, for example Josh and Sue. Older participants therefore showed increasing likelihood of rejection of the two theories or partial rejection due to provisos, as some of the older individuals had knowledge of and were influenced by the alternative and discredited theories of Steady State and Panspermia, providing further evidence against the views of Dawkins (2008), Verhey (2005), Moore (2007), Moore and Cotner (2009), Moore et al (2011) and Wiles and Alters (2011), blaming religion for the rejection of the scientific theories.

Partial acceptance/rejection

Study data of partial or different degrees and levels of acceptance or rejection of the science theories confirmed that some participants have partial or differing degrees of rejection, confirming the complex nature of views on the theories, which are not straightforward. In addition, an individual can hold differing views on each theory, for example Barbara rejecting elements of biological evolution while accepting the Big Bang, thereby confirming that both theories are considered on their own merits.

Review/change of view

Study data confirm that some participants had changed their views of both theories at various ages, for example Dean. Some participants also confirmed their views may change in

the future, for example Peter, as both the Big Bang and biological evolution are scientific theories that can be proved wrong, or altered, due to new scientific findings.

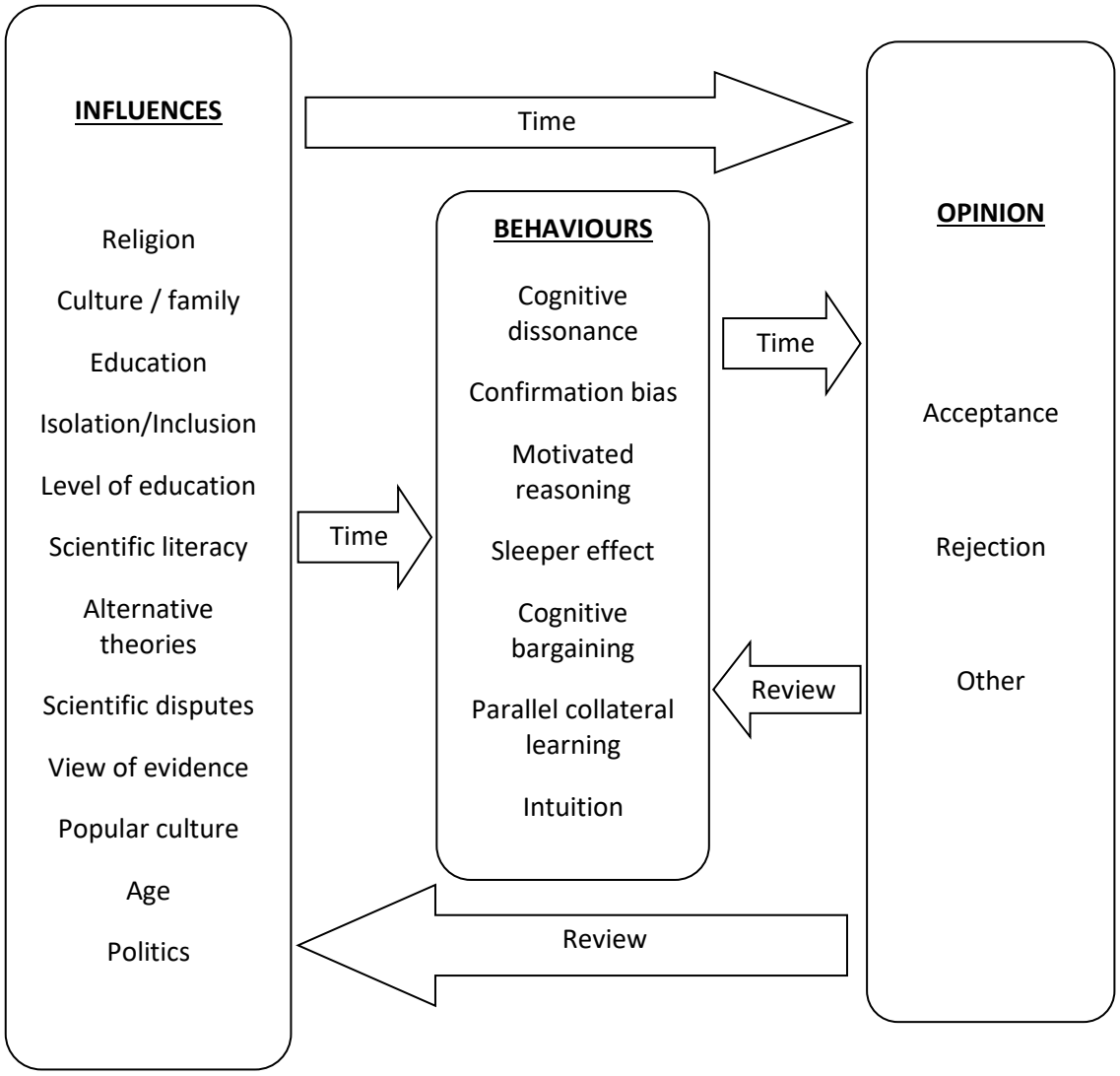
6.2.4 Theory of opinion formation specific to the Big Bang and biological evolution

The study has shown that within the sample half confirmed they reject in whole or in part either the Big Bang theory or the theory of biological evolution or both. There are different and occasionally multiple reasons for the rejection or acceptance of either the Big Bang theory or the theory of biological evolution and some individuals accept the Big Bang but not biological evolution, and vice versa. Differing reasons and influences from their life history explain this phenomenon, for example the difference between age groups for the occurrences of non-acceptance and acceptance where, those participants aged between teenage to their 30s accepted both theories, while older participants showed increasing likelihood of rejection of the two theories.

This indicates a theory of opinion formation underpinned by the data overview, which challenges the Dawkins and Moore orthodoxy of blaming religion for rejection of the Big Bang and evolution. The existing literature of Turner and Oakes (1986), Tajfel (1982), Kegan (1982), Fowler (1995), Glover (2014), Kim (2022), Chacoma and Zanette (2015), Medo, Mariani and Liyuan (2021), Chan, Duivenvoorden, Flache and Mandjes (2024) detailed in the literature review, suggest individual's opinions are formed and reformed over time. An individual can belong to a group that share a viewpoint (Turner and Oakes, 1986), resulting in collective identity (Tajfel 1982), via stages of development of the viewpoint (Kegan, 1982), and stages of faith that include intuition (Fowler 1995). Belief is subjective not objective (Kim 2022) and can include irrational belief (Glover 2014). Opinions are formed via a progressive evolution of a view (Chacoma and Zanette, 2015) and can have an effect on the individual and society, (Chan, Duivenvoorden, Flache and Mandjes, 2024), including when misleading sources influence opinion, (Medo, Mariani and Linyuan, 2021). This study, informed by these theories, confirms that the opinion formation specific to the scientific theories of the Big Bang and biological evolution are complex, multifaceted, and multilayered. From early childhood the process of opinion formation is not a one-off decision but is instead a process that can take shape from all aspects of life from birth to old

age, resulting in a developmental process of stages in opinion, confirming that the process of meaning-making to form perspectives and opinions is a lifelong activity. The rejection or acceptance of scientific theories may not exclusively be the result of rational propositional logic but may instead be inextricably enmeshed within the context of their life experiences, including educational and religious influences, and knowledge of old rejected scientific theories that remain influential, especially among older participants. The theory of opinion formation underpinning this thesis can be summarised in the following figure:

Figure 11. Theory of opinion formation specific to the acceptance or rejection of the Big Bang and biological evolution, supported by the study data



This original theory of opinion formation illustrates the influences from early childhood to older age, for example education or alternative theories, which can either directly result in an opinion concerning the two scientific theories or can result in behaviours that impact on the opinion, for example cognitive dissonance and its avoidance. Over time, opinions can change due to altered or new influences or behaviours, resulting in a personal review, with the process of opinion formation restarting and occasionally altering existing views, including the acceptance or rejection of the two scientific theories.

6.3 Study data that refutes or aligns with existing literature

The effect of rejection of both theories in science education is mentioned by Imgram (2011) and Sang (2011) but without examination of the many possible underlying causes. Religion is examined as a cause for rejection by Dawkins (2006) and Pew (2015) but without considering any other influences. The spectrum of religious influence and implications are discussed by Nelson (2000) and Skehan (2000) but again do not consider other factors. Some previous studies have been too narrow, for example the Pew (2009) reductive methodology concerning evolution alone. Existing research has too often concentrated on rejection of scientific theories because of religious belief alone, mostly undertaken in the United States and concentrating on the theory of evolution, without consideration of the Big Bang theory (Skehan 2000, Nelson and Skoog 2000, Pew 2009, Moore, Brooks and Cotner 2011, Moore and Cotner 2013).

The influences data does not suggest the need for a paradigm shift in science education to multiculturalist practices proposed by Cobern and Loving (2004), Spencer (1996), Aikenhead (1997) and Kawagley et al (1998), who never examined the effect of either education method specifically on the acceptance or rejection of the Big Bang or biological evolution. Isolation and inclusion are discussed in several papers but never specifically concerning the teaching of the Big Bang nor evolution, for example in Hodson (1998), Tobin (2004), Biggs and Tang (2011) and Kiwan (2012). Use of historical narrative is recommended in several papers including Bruner (2004), Green (2004) and Hawking and Lawton (2018) and is supported by this study, where participants who recalled it being used in their science lessons talk of it positively, with the important proviso of Matthews' concern of constructivism and multicultural practice, where care must be taken by teachers that they do not allow anything to count as science (1993 and 1997), that is also a concern of Skehan (2000).

Discussion of public scientific literacy, the importance of science education to a suitable age as a key subject in society and the concerning ability for some curriculum setters to 'opt out' of teaching the Big Bang and biological evolution were noted by Verhey (2005), Moore (2007), Moore and Cotner (2009), Moore et al (2011), and Wiles and Alters (2011), and are of equal concern in this study. Although there are several examples given in the literature

review of science disputes, poor communication and sometimes dubious claims by scientists, for example Ziman (2002), Merali (2007 and 2014) and Battersby (2017), the study participants could only convey unspecific knowledge of them, with vague recollections that scientists do not always agree.

The effect of age, gender and politics on acceptance or rejection of the two specific scientific theories has not been studied before in the UK. The influence of alternative discredited theories from the past, especially on older individuals is noted in participants of this study and confirms the lingering influence of Hoyle (1948, 1950, 1955 and 1983), noted by Barrow (1994). Popular culture has aided this lingering effect, that can result in rejection of the Big Bang and biological evolution, by propagation of the old alternative discredited theories, for example in Star Wars (Lucas 1980), Star Trek (Frakes 1993) and Alien (2023), although none of the participants of this study could name a specific film or influence from fictional books. There has not been a study undertaken before that examines the effect of fiction on the acceptance or rejection of either the Big Bang theory or theory of biological evolution.

The behaviours study data concerning the avoidance of cognitive dissonance, noted among some participants of this study, specifically concerning the Big Bang and biological evolution, has been noted for several decades, including by Lyttleton (1957), Sagan (1997) and most recently Packham and Cohen (2023a and 2023b). The avoidance is most noted in this study among older participants, especially by those who have knowledge of alternatives that do not produce feelings of unease, for example discredited theories or some religious beliefs. The data supports the suggestion of Otto (2016) concerning the influence of confirmation bias and motivated reasoning, where individuals may seek evidence that supports their existing beliefs of the origin of the universe and life on earth. The effect of intuition on the specific rejection or acceptance of either theory has not been studied before. In this study some participants find the theories intuitive and accept them, while others find them counter-intuitive and reject them. Mosley and Lynch (2010) suggest intuition can adversely affect an individual's views, for example some individuals around the world may still intuitively think, from observation, that the sun travels around the sky east to west and therefore around the earth, but Mosley and Lynch did not specifically examine the acceptance or rejection of the Big Bang nor evolution theories. The sleeper effect studied by

Colman, (2009) and Hogg and Vaughan, (2013) was not linked in their work specifically to the rejection of the Big Bang or biological evolution but has been in the data of this study. Cognitive bargaining was examined by Hull (1985) and the occurrence is noted in this study, where science theory is incorporated into personal belief. However, personal cognitive bargaining involving the two scientific theories has not been the subject of any specific study before. Similarly parallel or collateral learning have not been examined in the context of the Big Bang or evolution. Jegede and Aikenhead (2004), Jegede (1995) and Hodson (1998), were instead concerned with a broader discussion of parallel and collateral learning in the discussion of western science thinking versus cultural knowledge.

The data confirms individuals accept or reject the science theories on a spectrum ranging from total acceptance to total rejection, with partial rejection of elements of the theories between. The theories are assessed by participants on their apparent merits independently of each other, resulting in occasionally different views held by an individual on the Big Bang to biological evolution. These views can be revisited by the individual and may alter over time. This would agree with theories of belief and opinion formation suggested by, among others, Kegan (1982), Glover (2014), Kim (2022), Chacoma and Zanette (2015), Medo, Mariani and Liyuan (2021), Chan, Duivenvoorden, Flache and Mandjes (2024). However, none of these existing theories of belief or opinion formation have specifically examined the rejection or acceptance of the Big Bang nor biological evolution. This thesis proposes a specific theory of opinion formation to address the absence of research in this respect.

6.4 Summary of discussion

In summary, the study data derived from the qualitative life history research methodology indicates that each participant is affected by single or multiple factors that result in them individually accepting or rejecting either or both the two scientific theories. These findings counter the blame given to religion alone, that is found among others in Dawkins (2008). The research undertaken has confirmed that the rejection or acceptance of the scientific theories is not exclusively the result of rational propositional logic and is instead inextricably enmeshed within the context of an individual's life experiences. These multiple life experience factors that have an effect on the acceptance or rejection of the Big Bang theory

and theory of biological evolution include teaching methods, religious beliefs, science communication methods, lingering alternative outdated theories, participant age, psychological factors, levels of education and scientific literacy.

50% of interviewees rejected one or both theories in whole or in part despite both theories being easily explained, easily understood and possibly intuitive to a non-specialist audience, and neither theory requiring the use of an equation in its explanation. The literature review suggested there may have been explanations for the rejection of the Big Bang theory and the theory of biological evolution by lifelong learners; the effects of religious belief on science learners, differences in teaching methods, failings in science communication methodologies and academic disputes, the lingering effect of the discredited Steady State and Panspermia theories and psychological or psychosocial reasons, including cognitive dissonance, confirmation bias and possibly the sleeper effect. This is despite Singh (2004) suggesting both scientific theories of the Big Bang and biological evolution are easily understood and are not counter intuitive. Hoyle (1983) admitted that "I suspect that one of the reasons that the Big Bang theory has proven so popular is that it is an idea which, at the simplest level, is easy to grasp" (p.171).

While some academics have attempted to firmly blame religion for the rejection of both the Big Bang and biological evolution, (for example, Skehan et al 2000, Dawkins 2008, Moore et al 2011, Moore and Cotner 2013), religion does not explain the occurrence of rejection among non-religious individuals or atheists, some of whom, from the literature review, were scientists. The study also suggests that multiple factors and life experiences may have an effect on, and not simply an effect of, rejection or acceptance, as factors can compound an already existing position. Due to the multi layered and multi contextual nature of life, the data suggests that no two individuals' factors are the same and a factor or combination of factors that results in acceptance or rejection for one individual will not necessarily hold for another. This therefore suggests that the individuals' rejection or acceptance of the two scientific theories may not be answered by reductionism to undisputable independent variables, for example religion.

Among the participants there are different and sometimes multiple reasons for the rejection or acceptance of either theory. Different participants in the study accept the Big Bang but

did not accept biological evolution, and vice versa, and differing reasons and influences from their life history could explain the phenomenon. There are differing reasons between age groups for the occurrences of non-acceptance and acceptance. Individuals' views of both theories are formed throughout life, perhaps in part due to the process of forming a social identity, confirming the views of identity formation of Turner and Oakes (1986), and Tajfel, (1982). The complex processes of opinion formation are not one-off decisions to accept or reject theories or doctrines, thereby supporting the views of Kegan (1982). It is instead a process that can continue through life, taking shape from all aspects from birth to old age, resulting in a developmental process of stages in opinion, supporting Fowler (1995). Views are often subjectively not objectively formed (Kim 2022) and are occasionally irrational (Glover 2014). An individual's opinion formation can involve an evolution of a view (Chacoma and Zanette, 2015) and misleading sources can influence the opinion (Medo, Mariani and Linyuan, 2021). Opinion formation can play a significant role in societies, for example regarding the MMR vaccine and covid-19 measures (Chan, Duivenvoorden, Flache and Mandjes, 2024). The analysed study data therefore supports the concept that the process of meaning-making to form perspectives and opinion formation is a lifelong activity, often revisited and altered by the individual at different points in time, illustrated by the thesis' theory of opinion formation that is specific to the two scientific theories.

CHAPTER 7: CONCLUSION

7.1 Synopsis

The subject to be studied in this thesis was the rejection of the Big Bang theory and the theory of biological evolution by some lifelong learners, despite the time that has elapsed since the original theories were proposed. This is a problem as subject teaching and learning may be adversely affected by the rejection of the theories of the Big Bang and biological evolution in favour of, for example, a belief in a 6,000-year-old created earth and created life (Osborne 2011 and Ingram 2011). Rejection of either theory, which may restrict lifelong learners' subject choices, may also in turn result in exclusion from some learning pathways and reduced employment options (Dawkins 2006 and 2008, Osborne 2011 and Ingram 2011). Not only is the learning of science subjects affected by the rejection of the two scientific theories, but also interdisciplinary subjects and humanities, for example the History of Art, where human art dates from approximately 51,200 years BP (Oktaviana et al, 2024).

The research questions to be answered were:

1. What are the factors over an individual's life course that can result in the individual accepting or rejecting the two scientific theories of the Big Bang and biological evolution?

2. Upon identifying the factors, can recommendations be made to alter the practices within science education and practices of the dissemination of scientific theories to counter influences that unduly impact acceptance?

The research aims accompanying the questions were:

1. To examine the life histories of the participants and their opinions concerning the two scientific theories.

2. To identify how the participants' opinions developed.

The study aimed to pursue Mertens' (2015) description of systematic enquiry so that the resulting analysed and interpreted data could be used to address the issue of rejection and acceptance of scientific theories.

Studying respondents' life histories revealed significant insight into the factors that influence the acceptance or rejection of the Big Bang theory and the theory of biological evolution. The literature review suggested thematic reasons for the rejection of either or both theories. The review also noted however, that Singh (2004) suggests both scientific theories of the Big Bang and biological evolution are easily understood and intuitive, and that Hoyle (1983) confirmed the Big Bang was easy to grasp, without the need for equations. Yet, some individuals do not accept either or both theories, either in whole or in part.

7.2 Limitations of the study

Although a life history approach does provide "evidence based" findings (Cohen et al, 2011, p. 552 and Patton, 2015, p. 434), that are "accurate representations" of data (Baker, 2009, p. 10), it does not provide categorically conclusive proof, but instead provides a subjective process designed to establish the life history experiences that have influence the participant's acceptance or rejection of the Big Bang theory and the theory of biological evolution. The life history approach provides first person data, in context. The researcher's role is one of interpreter/co-meaning maker of the data and to make the most appropriate interpretation of what the participants say, from the basis of the researcher's own world view. This study does not attempt to claim absolute generalisability to the UK. However, the findings do have potential for significance in teaching and science communication, and the study adds to the body of existing knowledge and papers. Although Baker confirms Tagg's 1985 view that "saturation point is achieved when interviews with further respondents only add information about those individuals rather than to the groups to which they belong" (2009, p. 17), the findings and conclusions can be tested by follow up post-doctorate research in the UK and other countries.

7.3 The original contribution to knowledge that the study provides

The existing literature detailed in the review chapter either links just one influence with rejection of either theory or did not make the link between the influence and rejection of either of the two specific science theories at all. This thesis, for the first time, connects the dots of existing literature with the original findings from this study, resulting in one overarching theory of opinion formation specifically concerning the two science theories of the Big Bang and biological evolution. This study makes an original contribution to knowledge by examining acceptance or rejection of the two scientific theories based on respondents' life histories: that has never been done before. The study has shown that individuals are affected by single or multiple factors from their life history that result in them accepting or rejecting either or both scientific theories. The study has shown that the rejection or acceptance of scientific theories is enmeshed within the context of their life experiences, including their educational, religious and psychological influences, from birth to old age. No previous study of either theory's rejection has shown this to be the case.

Previous studies have instead concentrated either on a single factor or small numbers of factors, for example religion and politics, as in Dawkins (2008), Verhey (2005), Moore and Cotner (2009), Moore et al (2011) and Wiles and Alters (2011). These previous studies were inadequate and misleading because of their lack of depth and breadth. This study has not concentrated on one theory, for example biological evolution, that was the subject of some previous studies (Moore, 2007 and Pew, 2009) but has instead uniquely examined the position of two science theories, concluding that, in both, the rejection and acceptance position of the individual is the result of multiple factors from their life experiences. No previous study has examined the position of multiple scientific theories within one life history methodology and no previous study has examined the factors that result in the rejection of the Big Bang theory alone, or as part of a group of theories. Therefore, this study contributes new knowledge about the individuality of opinions concerning science theories in the minds of participants and their ability to assess, reject or accept theories on an individual merit basis, and not reject science as a whole.

The views closest to this study's findings are those of Turner and Oakes (1986), Tajfel (1982), Kegan (1982), Fowler (1995), Glover (2014), Kim (2022), Chacoma and Zanette (2015), Medo, Mariani and Liyuan (2021), Chan, Duivenvoorden, Flache and Mandjes (2024), where an individual's views are formed over time, involving a process of opinion formation and not one-off decisions on acceptance or rejection. However, these existing works only informed the methodology and discussion. None of these studies specifically examined, via a life history methodology, the rejection of the Big Bang nor evolution. This study has shown that the process of opinion formation concerning the two scientific theories takes shape from all aspects of life from pre-school to old age. The study identified a developmental process of stages in opinion, confirming that the process of meaning-making to form perspectives and opinion formation is a lifelong activity, enmeshed in the context of life experiences, and not necessarily the result of rational propositional logic. These multiple life experience factors that have an effect on the acceptance or rejection of the Big Bang theory and theory of biological evolution include teaching methods, religious beliefs, science communication methods, lingering alternative outdated theories, levels of education and scientific literacy.

The study findings and conclusions are original as they distinguish between the influences and behaviours that can affect acceptance or rejection of the two scientific theories. Influences on the individual through life, for example religion and education are different from behaviours that can result from influences, for example confirmation bias and cognitive bargaining. This clear differentiation is not found in the other papers concerning opinion formation. Religion, given as the source of conflict by Dawkins (2008), does not explain the occurrence of rejection among non-religious individuals or atheists. The study suggests that multiple factors and life experiences may have an effect on, as well as an effect of, rejection or acceptance, depending upon the individual. Due to the multi layered and multi contextual nature of life, the data suggests that no two individuals' factors are the same and a factor or combination of factors that results in acceptance or rejection for one individual will not necessarily hold for another. This therefore suggests that the individuals' rejection or acceptance of the two scientific theories may not be answered by reductionism to undisputable independent variables. Among the participants there are different and sometimes multiple reasons for the rejection or acceptance of either theory. Different participants in the study accepted one theory but not the other, and differing reasons and

influences from their life history explain the phenomenon. Further, there are differing reasons between age groups for the occurrences of non-acceptance and acceptance.

This study makes an original contribution to knowledge by confirming findings that include evidence to support the use of historical narrative within science lessons, including from the history of science and the history of often older explanations, including religious stories. Based upon the findings of this study, these assist in the communication and understanding of scientific findings and theories. Historical narrative of how and why science has developed and how and why specific scientific theories came into being is an essential element of science communication and science education. The study suggests there is no need for a paradigm shift to all schools promoting multicultural science education because inclusive learning methods alone, including using historical narrative, can reduce feelings of isolation and promote inclusion while teaching science (Tobin 2004 and Petty 2009). Although a shift to multicultural science education is not recommended by this study, integrated subject teaching in some lessons may assist learning in secondary schools and may help provide students with more understanding of the interlinked nature of subjects like science, history and religion. This view is supported by Ingram who suggests that "science and religious views are not, of necessity, mutually exclusive. If a school feel that this is an important issue to its students, then some form of collaboration between Science and Religious Studies might be developed" (2011, p. 239).

The study also suggests that the failures of science communication methods used by scientists and disseminators of scientific communications, have contributed to the rejection by some learners of the two scientific theories. Public announcements that have not been through any peer review process illustrate Wager's opinion of peer review being a hallmark of scientific credibility (2009). Peer review stops unfounded claims by rogue scientists with agendas that can have detrimental effects, (for example Wakefield et al 1998). Publications that have not been peer reviewed, for example the interviewee Roger's example of Psarris (2012), served only to confuse learners and give an impression of science being at odds with itself, with little consistency among scientists concerning the Big Bang and evolution. However, with ever increasing levels of online information it is impossible to prevent publication of non-peer reviewed assertions. Although Psarris indicates fundamentalist Christian belief may indeed be a factor in the rejection of the two theories for some

individuals, the study suggests that the position is much more complex with several factors at work, thereby supporting the views that individuals' opinions are formed over time, where opinion formation is a process that continues and changes throughout life.

This study's new theory of opinion formation, underpinned by the data overview, challenges the Dawkins and Moore orthodoxy of blaming religion for rejection of the theories. Religion in some instances may instead assist in the acceptance of scientific facts and theories among some learners. This developmental process of opinion formation takes shape from all aspects of life from birth onwards, as the analysed study data supports the concept that the process of meaning-making to form perspectives and opinion formation is lifelong. The rejection or acceptance of scientific theories is enmeshed within the context of the participants' life experiences.

Although all participants could define both theories to various degrees, scientific literacy cannot be measured by the acceptance of both theories. Several examples can be given of scientists and scientifically literate academics rejecting either or both theories at a point in their lifetime, for example Hoyle never accepted the Big Bang theory and not accepting biological evolution without a cosmic addition until his death in 2001 (Hoyle, 1983, 1990, 1994 and Singh, 2004). Einstein for several years rejected the Big Bang, preferring his own static theory (1917), Hawkins similarly rejected the Big Bang until undertaking his PhD (2013), Lennox rejected both theories without the addition of the Christian God actively participating and altering both while in progress (2009, 2011a and 2011b), and Flew in later life rejected his past atheism and argued for an intelligently designed and periodically intelligently altered version of the Big Bang and biological evolution, that did not conform to the scientific theories, (Flew and Varghese, 2007). Similarly, some participants of this study could define and understand both theories, and yet rejected one or both, in whole or in part.

Religion does not explain the occurrence of rejection of one or both theories by the study participants that are not religious or are atheists, as found in the wider community some notable scientists like Hoyle (1983, 1990 and 1994). The study findings of religious participants accepting both theories are in accordance with important historical changes in the doctrines of some faiths, for example the 1951 declaration of Pius XII confirming the

acceptance of the expanding universe by the Roman Catholic Church (Farrell, 2010). Today Roman Catholics are free to accept either theory, on the basis of both being the actions of God (Spitzer 2010 and Cusworth 2014). However, the study data confirms the findings of Pew (2009), that, despite official positions from religious leaders of faiths, identification with a particular religion does not appear to determine acceptance or rejection of scientific theories by the individual. Instead, the ability of some religious movements to be a broad church of opinions, appear to result in there never being a categoric wholesale opinion of members on the two theories. Individuals that identify with all religions taking part in the survey resulted in no single faith position proving 100% acceptance or rejection. The Church of England's and the Anglican Communion's positions on the Big Bang theory and on the theory of biological evolution are that members are free to accept or reject either theory, as both theories are compatible with God's work and existence (Williams, 2012). This study finds that regardless of the positions of religious leaders, identifying with a particular faith does not provide an automatic indicator of an individual's views of the science theories.

The broader cultural implications of this study help move beyond a dualistic, polarised split between science and religion. Inclusion of different perspectives within science teaching can improve the internalisation of scientific views. Committed religious people also hold scientific views about the universe, for example Lennox (2009, 2011a, 2011b). There is more common ground between the two domains of human experience of religion and science than some, such as Dawkins (2006 and 2008) and Moore et al (2011), accept. The research therefore supports the work being carried out by those trying to bridge the gap between science and religion in areas of society, for example the Vatican Observatory that was established by the Roman Catholic church "for astronomical research and public outreach to advance the scientific understanding of our universe" (vaticanobservatory.org, accessed 18.01.2024), the office of The Royal Society Professor for Public Engagement in Science (royalsociety.org, accessed 18.01.2024), and AAAS Dialogue on Science, Ethics and Religion, that was established in 1995 by the American Association for the Advancement of Science (sciencereligiondialogue.org, accessed 18.01.2024).

A broader philosophical and psychological point concerns personal meaning-making that connects to the study methodology. The theory of narrative identity would suggest that the concept of story is intrinsic to development of a coherent sense of self and this coherence is attained as we align ourselves with larger, cosmological stories which then assign our particular 'stories' with their significance (McAdams, 2001). The concept of human origins (whether understood through mythological retelling or scientific accounts) may not be fully addressed or comprehended except through this very human medium of story. As 'storying' beings, we understandably reach towards all available narrative accounts of our origins, in order to help achieve psychological coherence, as Jung (1959) suggests.

In this study the two scientific theories are not accepted more by those older participants with a fully developed frontal cortex, rather than by the teenage participants with developing frontal cortex, all of whom accepted both theories. This suggests that the reason for acceptance or rejection is complex and due to many external influences, as well as the brain's ability to comprehend. The development of the frontal cortex by neuroplasticity due to ageing is normally accomplished by the age of 25 and assists in complex and advanced theories like the Big Bang and evolution to be contemplated by individuals (Seitz and Angel 2020, Luna et al, 2022 and Perica et al, 2022). It could therefore be suggested that scientific theories might be more accepted by older participants, but this study has found the opposite. This suggests rejection can be deep seated in an older individual due to their longer life history and therefore greater number of life experiences, influences and resultant behaviours, which lead to opinion formation, and resultant acceptance or rejection of the two scientific theories.

This original study proposes the psychological reasons why individuals reject scientific findings and scientific theories, including avoidance of cognitive dissonance, confirmation bias, the sleeper effect and cognitive bargaining. Feelings of unease about both theories are not specific to the early decades of the proposal of the theories and may well continue into the future, as the avoidance of cognitive dissonance is hard wired in the human brain. Therefore, the rejection of either or both theories by some learners is an inevitable and possibly unchangeable consequence of the advanced nature of human thought. Although science teaching methods can be altered and science theory dissemination can be achieved

in a more consistent way, the rejection of science theories by some learner may never be fully overcome, due to the vast complexity and individuality of opinion formation.

Hoyle (1953) confirmed his personal feelings of insecurity and the possibility that he continued to reject the dark cold death of the Universe, not on the basis of science, but on the basis of fear of the theories implications, resulting in his continued promotion of the Steady State theory (1962 and 1983). Lyttleton confirms that his preference for the Steady State theory is due to its aesthetic nature, and no need for an eventual dark cold end (Lyttleton, 1957). This confirms that factors, other than scientific evidence, influenced some notable internationally recognised scientists, as well as some of this studies' participants, to reject the Big Bang theory and evolution. The feelings aroused by astronomy among scientifically literate individuals, some feelings of which are not scientifically based, were well termed by Lyttleton as "cosmic emotion" (1957, p. 5). Several other scientists and academics have written of their occasional depression concerning modern cosmogony and astrophysics, for example Heilbron (2015), Weinberg (1993) and Pyke (1963). Packham and Cohen (2023a and 2023b) propose that areas of evolution and cosmology involve uncomfortable truths, leading some to feelings of unease about both theories, that are not specific to the early decades of the theories propagation.

Two human pillars of the scientific theories that are the subject of this thesis were both Roman Catholic priests; Friar Gregor Mendel, the founder of modern genetics that would become vital to the theory of biological evolution (1866), and Friar Georges Lemaitre, the first to propose the theory of the origin of the expanding universe, that would become known as the Big Bang (1927). These two individuals are part of the evidence against Dawkins' view that religion is to blame for the rejection of scientific theories (2006 and 2008). Science and religion can be and often are compatible. As the literature review noted, Sherwood (2011) confirms the potential lengthy timescales of scientific theories becoming widely accepted in the scientific community and the overlap that occurs in their being accepted by a "public" audience. His paper gave the examples of heliocentrism, general relativity and global warming and the lengthy periods it takes for, firstly scientists and subsequently the general population, to accept new scientific theories as proven.

The theoretical physicist Max Planck confirmed the lingering effects of old theories are common in the history of science as, in his view:

> A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.
>
> (Planck cited in Thompson, 2017, p. 60).

This view is in accordance with the study findings concerning the link between rejection and the age of the participant.

7.4 Final thoughts on the study

The study data of younger verses older participants suggests that if this study were repeated in several decades time the number of participants that reject the Big Bang or biological evolution may have decreased. The continued rejection of both theories is due to a combination of influences and behaviours detailed in the thesis' theory of opinion formation, together with the inevitable consequence of the time scale it takes for old theories and their supporters to die out. However, as alternative explanations of the universe and life will always exist, including scientific and religious ones, there may never be a time when both the Big Bang and biological evolution are accepted by all, without question. An increased use of historical narrative in science lessons, together with proactive cooperation between school departments illustrating the links between humanities and science subjects, may at least assist and provide those that doubt the two theories time and space to discuss the theories merits and come to a balanced conclusion on their validity. However, the validity of a current scientific theory will only last as long as any future alternative theory takes to be formulated and supported by evidence. Unknown future factors may also impact acceptance and rejection. It was noted in the literature review that the Chinese government officially rejected the Big Bang for decades in the 20th century, and so too could a future government, in say America, if a religiously fundamentalist President and party came to power. Perhaps the key to understanding the problem of rejection is for individuals to be allowed to choose freely on accepting or rejecting scientific theories. They

must not be forced nor coerced to accept. Instead, learners should be respected, understood and included in discussion, no matter what their view. They must be given all available evidence that supports both scientific theories and given appropriate respect for any deeply held personal beliefs. What follows will be up to their own personal opinion formation.

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Appendices

1. Interviewee Information Sheet
2. Interviewee Consent Form
3. Interview Schedules
4. Post interview checklist
5. Example of coding
6. Link to transcripts and data archive

Appendix 1. Interviewee Information Sheet

University of

Reading

Principal Researcher: Ian Blagrove

Phone:

Email: I.S.G.Blagrove@pgr.reading.ac.uk

Interviewee Information Sheet

Research Project:

A life history study of the factors that influence the acceptance or rejection of the Big Bang theory and the theory of biological evolution among lifelong learners.

Dear Participant,

I am writing to invite you to take part in a research study about science education.

What is the study?

Recently I contacted you about a study I am conducting at the University of Reading. The study aims to investigate the reasons why individuals accept or reject two scientific theories: The Big Bang and biological evolution. The study aims to inform teachers and scientists of the reasons individuals either accept or reject each theory. The results may help teachers modify their lessons, and teaching practice, and may help scientists modify their methods of communicating science to learners and society as a whole.

Why have I been chosen to take part?

You have been chosen to take part following my conversation with you where you expressed an interest in the study. In addition, you have been selected to give a balance to the study so that it is representative of individuals in the Reading area from the age of 18 to retirement.

Do I have to take part?

It is entirely up to you whether you wish to participate. In addition, you may also withdraw your consent to participate at any time during the project without any repercussions to you by contacting the researcher: Ian Blagrove

Phone: Email: I.S.G.Blagrove@pgr.reading.ac.uk

What will happen if I take part?

With your agreement participation will involve two interviews that ask questions about your life history that may help explain your acceptance or rejection of the two theories. The first interview is designed to take between 30 minutes and 1 hour to compete. The second interview that builds on the first is designed to take between 1 and 2 hours. Both interviews can be undertaken on the same day with a break in between or they can be undertaken on separate days, if that is more convenient to you. The interviews can take place either at your home or alternatively at the University in Reading or local community centre. With your consent the interviews will be recorded and transcribed. The recordings will be held securely by the University of Reading for five years unless you ask for them to be permanently deleted after they are transcribed.

What are the risks and benefits of taking part?

The interviews and information given by you will be anonymous and you as a participant will be given a first name other than your own for which the interview information and you will be known by. The anonymised data will form part of the study findings and will form part of a PhD thesis written by the researcher, Ian Blagrove.

Participants in similar studies have found it interesting to take part. The University anticipates the findings of the study will be useful to both teachers and scientists and the findings may be published in UK and international journals and periodicals.

What will happen to the study data?

Any data collected will be anonymised. No real names will be used in the study or any subsequent publications. Research records, including any interview recordings, will be stored securely in a locked filing cabinet for five years. The results of the study will be

presented in the PhD thesis, at national and international conferences and in written reports and articles.

What happens if I change my mind?

You can change your mind at any time without repercussions. If you change your mind after the data collection has ended and before publication your data will be deleted.

What happens if something goes wrong?

In the unlikely case anything goes wrong or if you have a concern or complaint you can contact the research supervisor:

Dr Geoff Taggart.

Phone 0118 378 2601 Email: g.taggart@reading.ac.uk

Where can I get more information?

If you would like more information, please contact Ian Blagrove

Phone: Email: I.S.G.Blagrove@pgr.reading.ac.uk

I hope you agree to participate in the study. If you do please complete the attached consent form and return it to me, sealed, in the pre-paid envelope provided.

This project has been reviewed following the procedures of the Reading University Research Ethics Committee and has been given a favourable ethical opinion for conduct. The University has the appropriate insurances in place. Full details are available on request.

Thank you for your time.

Yours sincerely,

Ian Blagrove

Appendix 2. Interviewee Consent Form

University of

Reading

Principal Researcher: Ian Blagrove

Phone:

Email: I.S.G.Blagrove@pgr.reading.ac.uk

Interviewee Consent Form

I have read the Interviewee Information Sheet about the research project and I received a copy of it.

I understand the purpose of the project and what is required of me. All my questions have been answered.

I consent to my involvement in the project as outlined in the Interviewee Information Sheet.

Signed: ……

Name: ……

Date: ……

Appendix 3. Interview Schedules

STAGE ONE SHORT INTERVIEW - PARTICIPANT DETAILS

Sub-section:	**Discussed**
INTRODUCTION	
Provide the participant with the introduction to the study	**[ ]**
Explain the study aims	**[ ]**
Detail the participant prerogatives	**[ ]**
BACKGROUND INFORMATION OF PARTICIPANT	
Name	**[ ]**
Your age	**[ ]**
Student / Self Employed / Employed / Unemployed / Retired	**[ ]**
Description of work/study undertaken	**[ ]**
Would you describe yourself as an atheist / agnostic / theist / other?	**[ ]**
Your Religion (if applicable)	**[ ]**
Would you describe yourself as culturally Christian (amend religion as required)	
or practicing Christian (amend religion as required)?	**[ ]**
Are you practicing / do you attend a place of worship Yes/No	**[ ]**
If yes, how often	**[ ]**
What political party do you think you are most aligned to	**[ ]**
Did you study at school up to 16/18, or Degree/Masters/Doctorate?	**[ ]**
How would you describe your ethnicity?	**[ ]**

CONFIRMATION OF UNDERSTANDING OF THE TERMS TO BE USED

How would you define the Big Bang theory? **[ ]**

How would you define the theory of biological evolution? **[ ]**

CURRENT VIEW OF THE TWO THEORIES

Do you agree with/accept the Big Bang theory? Yes/No/In part **[ ]**

Why do you think that? **[ ]**

Do you agree with/accept the theory of biological evolution? Yes/No/In part **[ ]**

Why do you think that? **[ ]**

Do you think the Big Bang theory is intuitive or counter-intuitive? Why? **[ ]**

Do you think the theory of biological evolution is intuitive or counter-intuitive? Why? **[ ]**

Thank you. The second interview will seek to establish what factors and events in your life history have led you to your views on the two theories. Would you like to proceed with the second interview now? **[ ]**

STAGE TWO MAIN INTERVIEW – LIFE HISTORY AND LIFE EXPERIENCES

Section	**Discussed**
INTRODUCTION	
Explain the purpose of the second longer interview	**[ ]**
Detail the participant prerogatives	**[ ]**
PERIODS IN LIFE AND GROUP THEMED QUESTIONS:	
Parents/Family background	
Please tell me a little about your parents/careers.	**[ ]**
What do you think are/were their views on the two science theories?	**[ ]**
Why do you believe they thought this?	**[ ]**
Please tell me a little about your wider family/siblings.	**[ ]**
What do you think are/were their views on these two theories?	**[ ]**
Why do you believe they thought this?	**[ ]**
Preschool years	
What is your earliest memory do you think?	**[ ]**
Do you recall being read bedtime stories?	**[ ]**
Were they nursery rhymes, religious stories, songs?	**[ ]**
At this age do you remember being read or told stories of how the world and life came about, and if so what were they?	**[ ]**
At the time were these accounts believed by you?	**[ ]**
Primary school	
Can you recall your first days at school?	**[ ]**

Was your primary school a faith-based school? **[ ]**

What format did your primary school assembly take? **[ ]**

Did your primary school have designated science lessons? **[ ]**

Where there designated religious study lessons? **[ ]**

Before school lunch did the school children pray? **[ ]**

What were you taught at primary school were the origins of the universe? **[ ]**

What were you taught were the origins of humans? **[ ]**

During your primary school years what did you believe were the origins of the universe and humanity? **[ ]**

Secondary school

Can you recall your first days at secondary school? **[ ]**

Was it a faith-based school? **[ ]**

How did school assemblies differ from primary school? **[ ]**

Did you study science to 16 or 18? **[ ]**

Did you take a religious studies exam at 16 or 18? **[ ]**

What were you taught in science lessons was the origin of the universe? **[ ]**

What were you taught in religious studies lessons was the origin of the universe? **[ ]**

What were you taught in science lessons was the origin of humanity? **[ ]**

What were you taught in religious studies lessons was the origin of humanity? **[ ]**

During your secondary school years what did you believe were the origins of the universe and humanity? **[ ]**

Did your secondary school science lessons allow debate about other explanations of life and the universe other than the theories of the Big Bang and biological evolution? **[ ]**

Did your secondary school religious studies lessons allow debate about non-religious explanations of the origins of life and the universe? **[ ]**

Did you ever feel culturally isolated or religiously isolated in science lessons at any school or college and if so can you explain the feeling? **[ ]**

Did you ever feel you held two views in parallel during science lessons: one scientific and one religious, and if so can you tell me about the two parallel views? **[ ]**

What science books and science encyclopaedias do you remember from your childhood? **[ ]**

Adulthood

Did you attend a university or college? **[ ]**

What subjects did you study and to what level? **[ ]**

Did your post school education affect your views of the Big Bang or biological evolution? **[ ]**

Please tell me about the main events in your life following leaving school/college/university to today. **[ ]**

During this period how have your religious view/views of religion changed? **[ ]**

How have your views on the two science theories changed? **[ ]**

When you have received evidence on either theory have your views ever changed and then changed back? **[ ]**

Do you think you ever look for evidence that supports your existing views? **[ ]**

If you follow a particular religion what does that religion teach about the Big Bang and biological evolution? **[ ]**

Do you agree or disagree with these views? **[ ]**

Have you watched TV documentaries or DVDs on the two science subjects? **[ ]**

What are your views of these documentaries/DVDs? **[ ]**

Do you think scientists agree or disagree with each other on the origin of the universe and life? **[ ]**

Why do you think this? **[ ]**

What do you know of the Steady State theory of the origin of the universe? **[ ]**

What do you know of the Cosmic theory of evolution/Panspermia? **[ ]**

Do you think it is possible to believe in God and accept the theories of the Big Bang and biological evolution? Why? **[ ]**

Why do you think other people accept or reject the Big Bang theory? **[ ]**

Why do you think other people accept/reject the theory of biological evolution? **[ ]**

Have your religious beliefs ever changed because of new scientific findings? **[ ]**

Feelings about the theories

How do you feel about the dark cold death of the universe given in the Big Bang theory?

Happy/Unconcerned/Not happy **[ ]**

Why do you feel this way? **[ ]**

How do you feel about biological evolution theory and its implications for the place humanity is within the range of living things? Happy/Unconcerned/Not happy **[ ]**

Why do you feel this way? **[ ]**

Participant's own summary

How would you sum up the reasons why you accept/reject the Big Bang theory? **[ ]**

How would you sum up the reasons why you accept/reject the theory of biological evolution? **[ ]**

Thank you for taking part in this study that aims to establish the factors that influence the acceptance or rejection of the two scientific theories among lifelong learners. Your contribution will be a useful addition to the study. Please keep the Interviewee Information Sheet for your future reference.

Appendix 4. Post Interview Checklist

POST INTERVIEW ESTABLISHMENT OF RELIABILITY AND VALIDITY

(TO BE COMPLETED AFTER THE INTERVIEW)

Participant number ..... Date of interviews ..... Setting ..... **[ ]**

Interaction

Did the physical setting have any effect on the study?

..... **[ ]**

Did any prior interaction affect the study?

..... **[ ]**

Was there any non-verbal communication or event?

..... **[ ]**

Was the verbal/vocal behaviour suitable?

..... **[ ]**

The participant

How was this participant representative of the population?

..... **[ ]**

How did this participant assist the study in being representative?

..... **[ ]**

Was there any evidence of misinformation, evasion, deception?

..... **[ ]**

Was there any evidence of self-deception of the participant?

..... **[ ]**

Was there any evidence of a "front" being presented?

..... **[ ]**

Was there any suggestion that information was not revealed?

..... **[ ]**

Was there any information or period that was forgotten or could not be recalled?

..... **[ ]**

Were any accuracy checks needed in the interview or after?

..... **[ ]**

Was there consistency in the information given by the interviewee?

..... **[ ]**

At any point was clarification asked for either by the researcher or participant?

..... **[ ]**

The researcher

Was your demeanour (clothing, speech, body language) suitable?

..... **[ ]**

Was your personality (warmth, hostility, anxiety) suitable?

..... **[ ]**

Did you avoid any expectation of answers?

..... **[ ]**

Did any information from the interview "please" you or "not please" you?

..... **[ ]**

Appendix 5. Example of coding

Excerpt taken from participant 3 first interview	**Code**
CONFIRMATION OF UNDERSTANDING OF THE TERMS TO BE USED	
How would you define the Big Bang theory?	
The world must have started somehow. I think God started the world including possibly by a Big Bang type of event. Expanding. It does not put me at odds with my Christian faith.	16,20 5,12
How would you define the theory of biological evolution?	
We can see evidence of evolution scientifically. Evolving. Moths in the industrial revolution. The darker ones did better than the lighter coloured ones because of the soot.	16,20
CURRENT VIEW OF THE TWO THEORIES	
Do you agree with/accept the Big Bang theory? Yes/No/In part and why?	
It does not put me at odds with my Christian beliefs. God could have started both the Big Bang and evolution. I am prepared to work with scientific theories and with the Bible.	5,12,4 16,20 18,19
Do you agree with/accept the theory of biological evolution? Yes/No/In part and why?	
Again, I am willing to work with scientific theories. They are theories that can be proved wrong at any point in the future. We can see evidence of evolution.	16,18 19,20
Do you think the Big Bang theory is intuitive or counter-intuitive and why?	
It's intuitive. People are trying to trace back to what we can find. To find evidence.	20,21
Do you think the theory of biological evolution is intuitive or counter-intuitive and why?	
Again, I think people are looking for theories that fit the facts, so intuitive.	20,21
Excerpt taken from participant 3 second interview	
Parents/Family background	
Please tell me about your parents/careers:	
Dad was a naval officer and came out of the navy about the time I was born. Mum basically looked after the home although she was also a tutor. I have siblings. Mum died when I was 16. Dad eventually remarried. Basically, a stable and loving home.	6
What do you think are/were their views on the two science theories?	
We were all root Christian, but we were not heavy church goers as kids. My father would have looked to the Bible.	6,5 19,17
Preschool years	
What is your earliest memory do you think?	
A concord stamp on an envelope.	
Do you recall being read bedtime stories?	
Yes	6
Were they nursery rhymes, religious stories, songs?	
A mix I think.	5
At this age do you remember being read or told stories of how the world and life came about, and if so what were they?	
Yes. A children's Bible. Broadly Christian and Biblical.	5,6
At the time were these accounts believed by you?	
Yeh.	17,5 18,19

CODES:

1 Employment status / job	**2 Teaching methods at school**	**3 Feelings of isolation during learning**	**4 Parallel and collateral learning**	**5 Belief / religion**	**6 Culture/family**	**7 Disputes in scientific community**
8 Alternative theories	**9 Cognitive dissonance**	**10 Confirmation bias**	**11 Sleeper effect**	**12 Cognitive bargaining**	**13 Politics**	**14 Age and gender**
15 Level of education	**16 Scientific literacy**	**17 Changes in viewpoint**	**18 Degree of acceptance / rejection**	**19 Total acceptance / rejection**	**20 View of evidence**	**21 Intuitive / counter – intuitive**

Appendix 6: Link to transcripts and data archive

https://reasearchdata.reading.ac.uk/id/eprint/447

Blagrove, I.S.G., (2023), *A life history study of the factors that influence the acceptance or rejection of the Big Bang theory and theory of biological evolution among lifelong learners. 20 interview transcripts*, University of Reading dataset