



Characteristics of the sciences

The origins of the universe, space and matter

There are some fundamental questions that most people ask about **the universe**:

- How old is it?
- How was it created?
- What has changed over time?

Unfortunately, nobody knows the answers to questions such as these and it is very unlikely that anyone ever will because, whatever hypothesis scientists may start with, they need evidence either to confirm or reject it.

Key term

the universe: all created things viewed together as one system or a whole. The universe is sometimes said to be everything that can be seen or measured.

Three of the main branches of science are:

- biological sciences (e.g. biology and biochemistry), which investigate the organic (living) nature of the universe
- Earth sciences (e.g. geology), which investigate the physical nature of the planet Earth
- physical sciences (e.g. chemistry and physics), which investigate the inorganic nature of the universe

In terms of evidence, scientists may consider:

- the Earth's geology and its oldest rocks and fossils
- computer models of the atmosphere and ocean
- techniques of molecular biology to study the relationship between life forms, perhaps with a view to identifying common ancestors
- undertaking laboratory experiments relating to early life forms
- studying life and survival rates under the most extreme conditions

Astronomers have succeeded to some extent in narrowing the gap in knowledge about the origins of the universe through their studies in cosmology. Of particular interest to cosmologists (astronomers who study and research the origin, structure and space–time relationship of the universe) are:

- an understanding of how galaxies have evolved from the distant past to the present
- a greater understanding of the scale of cosmic distances
- the testing of theories of the expanding universe

For a long time it was believed that the Earth was flat and even as late as the Middle Ages there were those who were afraid of falling off the edge, although as early as the fourth century BC the Greek philosopher Aristotle had suggested that the Earth was a sphere. Ptolemy developed Aristotle's ideas 500 years later, and put forward the view (the geocentric system) that the sun, the stars and all the planets revolved around the Earth in circular orbits.

In the sixteenth century, the Polish astronomer Nicolaus Copernicus changed the way we think about the solar system when he published *On the Revolution of the Heavenly Spheres* in 1543. Copernicus realised that the reasoning behind Ptolemy's model was wrong and put forward an alternative model (the heliocentric system), which placed the sun at the centre of the universe with all the planets, including the Earth, revolving round it. This challenge to the more established theory of Ptolemy was much disputed, especially by the Catholic Church, and the book was placed on the Church's Index of Forbidden Books for over two centuries.

Eventually, the invention of the telescope, and its use by Galileo, resulted in the end of Ptolemaic theory and confirmed the Copernican model. By the early seventeenth century, the German astronomer Johannes Kepler had developed the heliocentric model further by demonstrating that planets have elliptical, rather than circular, movements, giving us the laws of planetary motion.

Kepler's ideas on elliptical orbits were confirmed in the late seventeenth century by Isaac Newton, who used mathematical calculations to underpin his law of universal gravitation. Newton was concerned by his own belief that, because the stars of the universe attracted each other, they would eventually collapse into each other. We now know that this is not the case because the universe is not as static as Newton believed and gravitational collapse is prevented because the cosmos is in a state of expansion.

The issue of whether the universe has boundaries in time and space has been much debated. Some claim that the universe has existed for ever, whereas others claim it was created and there was thus a beginning in space and time. Enter the Big Bang theory.

Ask the examiner

Q What is the Big Bang theory?

A This is the dominant scientific theory about the origin of the universe and seeks to explain what happened around the time the universe began. According to this theory the universe was created anything between 10 and 20 billion years ago (probably between 12 and 15 billion years ago).

It is unlikely to have been the result of a big explosion as some originally thought, but scientists are unable to look back before the Big Bang began. For most scientists, the Big Bang was the instant when the universe started, when space and time came into existence and all the matter in the cosmos started to expand.

Most scientists believe that our universe began as a result of what some call a 'singularity' — something that was extremely small, intensely hot and highly dense — a 'fireball' or some sort of cosmic event. It took one second for the singularity to expand and cool, still intensely hot but cooling sufficiently for protons and neutrons to synthesise and form helium and hydrogen nuclei — building blocks for the formation of other elements. It is estimated that the Big Bang was over after 30 minutes.

Ironically, the name 'Big Bang' was said to have been popularised by the eminent scientist and science fiction writer Fred Hoyle, who disputed the claim that the cosmos was created some 12 billion years ago and who used the phrase 'Big Bang' dismissively in 1950.

The creation versus evolution controversy

- How did we get here?
- Did we evolve or were we created?
- Were we produced by some purposeful intelligence?
- What does the evidence say?

The Big Bang theory is the most widely believed by scientists. However, cosmogony (the study of the origin of the universe) brings together science and theology. If the universe had a beginning, is it possible that there was a master architect or intelligent designer? Put simply, religious believers ask: 'what role did God play'?

There are two competing theories relating to the origin of the universe and of life: evolution and creation (sometimes refined into what has become known as intelligent design). The creation versus evolution debate is ongoing and demonstrates wide differences in thinking about the origins of the Earth, life and the universe. Creationists take a primarily religiously based position while evolutionists

tend to reflect the scientific consensus, where there is overwhelming support for evolutionary theory. However, it would be an oversimplification to see this as a science versus religion debate.

The theory of creation reflects a belief in a divine Creator of the world and its life forms. Evolution stresses the natural descent of all living creatures from a common ancestor that originally evolved from inorganic matter.

The debate has many dimensions.

- In the USA, especially in the more southern states (the 'Bible belt'), Republican supporters are more likely to have creationist beliefs. In the UK creationists and evolutionists are not linked to particular political parties or drawn from identifiable geographical areas.
- In the USA there is also more controversy about what should be taught in schools, because the separation of church and state is an important part of the US constitution.
- Much of the debate is over what constitutes good science as opposed to belief, and what constitutes scientific evidence and research rather than theorising.

Evolution

- Early ideas of evolution (the idea that complex organisms have developed gradually from simpler ones over geological time) began to emerge after the late eighteenth century, mainly as more knowledge emerged about geology and fossils. However, public debate was rare because of the threat to contemporary religious teaching.
- The original 'evolutionist' was almost certainly the Frenchman Jean Baptiste de Lamarck, with his idea of what he called 'transformation'. Lamarck believed that an individual who had acquired characteristics during a lifetime could pass them on to an offspring to aid its survival. What he lacked was supporting evidence.
- It was Charles Darwin who made the vital breakthrough. As a 22-year-old interested in geology, Darwin joined *HMS Beagle* as a naturalist in 1831 when it set sail on a 5-year surveying expedition to South America and the South Pacific. His job was to keep records of everything he observed – which included thousands of species of organisms and a wide variety of fossils.
- *The Beagle* spent 5 weeks in the Galapagos, charting the archipelago and making careful observations about both the geology and biology of the islands, including their birdlife. Darwin began a notebook on evolution in 1837, and in 1845 a general account of his travels and research was published in *The Voyage of the Beagle*.

- By then, Darwin had developed his early thoughts on what he called ‘natural selection’ — that those individuals born with characteristics that make them best suited for their environment are the ones most likely to survive and produce offspring.
- In 1859, and by then an eminent scientist, Darwin published *On the Origin of Species by Means of Natural Selection*. By that time, Darwin had received an essay from another scientist, Alfred Russel Wallace, who was living in the Malay archipelago and who advanced very similar ideas to those of Darwin. The first print run of Darwin's book sold out in a day. The controversy was intense but Darwin's meticulous and detailed approach, over many years, gave great scientific credibility to the theory of evolution, although many Christians still opposed the idea.
- What Darwin was doing, however, was calling into question the creation story of the Bible, that God created the world in 7 days. His idea of natural selection, based on genetic characteristics, went against any form of divine plan.

Creationism

- Creationism is the belief that the universe was created literally according to the Bible's account, contained in the book of Genesis; as it has evolved over the past 80 years, it is sometimes known as Creation Science.
- Creationists tend to be fundamentalist Christians.
- As public education expanded in the USA in the early twentieth century, some began objecting to the teaching of scientific evolution based on Darwin's theory of natural selection because it explains the origins of life without mentioning God.

There are different interpretations of the creation stories, but creationists are usually divided into three groups:

- **New Earth creationists.** They believe that the Earth and its life forms were created by God in 6 days about 10,000 years ago, and that since then only very minor changes to species have happened.
- **Old Earth creationists.** They also believe that the physical universe was created by God but use a less literal interpretation of Genesis. Old Earth creationists tend to follow the timelines favoured by astronomers and geologists but question evolutionary theory.
- More recently, **neo-creationists** have tended to separate themselves from both New and Old Earth creationists, favouring the term ‘intelligent design’ (ID).

Science and religion

The scientific community has remained sceptical of what seems to be more a claim than a scientific theory. Science always requires proof, and this is difficult for religion to offer. Creation of the Earth by God or any other divine force does not offer a concrete scientific explanation of life's origins. It is the Bible versus Darwin's *Origin of Species*.

It is widely believed that science and religion are diametrically opposed and cannot be reconciled, because they represent separate categories of thought that ask different questions and use different methods to answer them. One is based on data and the other is part of a belief system. For many scientists, intelligent design does not represent what they understand as scientific research and is essentially creationism under a more attractive-sounding and neutral name. For supporters of ID, evolution is a theory in crisis with barely concealed divisions between scientists.

In the USA the creationist and ID movements are very well organised and funded, with support groups and research foundations across the country. They have a particularly large following in some states, and the mixture of religion, science and politics has often proved highly inflammable.

In 2005 a poll for CBS News showed that over 50% of Americans rejected the theory of evolution. In addition, while the Creation Museum in Cincinnati had no difficulty in raising £3 million in donations, insufficient sponsors came forward to support an exhibition celebrating the life of Darwin at the American Museum of Natural History in New York, because they were reluctant to be accused of being pro-evolutionist.

The position in the UK

- In the UK, similar divisions exist but the debate has been much more restrained. UK schools are required to offer teaching in religious education; and the science curriculum has, in broad terms, used evolution with minimal criticism.
- The Royal Society, the UK's national academy of science, has declared firmly in favour of evolution as 'the best explanation for the development of life on Earth'. It stated that, although there were many things that science could not explain and young people should be encouraged to explore scientific and other beliefs, they were not well served by attempts to 'withhold, distort or misrepresent scientific knowledge and understanding in order to promote particular religious beliefs'.
- Similar views have been expressed by the Association for Science Education, a body for teachers of science. It stated that, when compared with the rationale used

to distinguish between 'good' and 'bad' science, 'ID has no grounds for sharing a platform as a scientific "theory"'; and that 'creationism, like ID, is not based on scientific evidence and, as such, is not scientific theory'.

- The Royal Society has criticised supporters of intelligent design for using evidence selectively and for treating any gaps in knowledge as if they were evidence for a 'designer'. It sees evolution as supported by the weight of scientific evidence and intelligent design as not.
- Nevertheless, by the end of 2006 some schools were using creationist teaching materials deemed by the government to be 'not appropriate to the science curriculum'. Teaching packs, including two DVDs, were sent to heads of science in all secondary schools by an organisation called Truth in Science.
- Of the 89 schools that returned the feedback postcard, 58 responded positively. Truth in Science claimed that its main intention was to encourage schools to look critically at Darwinism, and that supporters of intelligent design believed that there was empirical evidence for a 'designer'.
- Many schools, and even university departments, might teach creationism to show an alternative to Darwin's theories, although many scientists prefer a science curriculum based on science rather than faith and prefer scientific fact to what others argue is biblical fact.
- Nevertheless, the government has made it clear that 'neither intelligent design nor creationism are recognised scientific theories and they are not included in the science curriculum'. Phil Willis MP, a former teacher and chair of the parliamentary Science and Technology Select Committee, described the teaching of a creationist approach to science alongside Darwinism as a development that was 'deeply worrying'.
- The controversy goes on and has been re-awakened in the Catholic Church. In 2006 a group of scientists and philosophers visited the Vatican to discuss intelligent design with Pope Benedict XVI, a former theology professor, and it is felt that he is increasingly sympathetic to the creationist position.
- Because the theory of evolution and its mutations over hundreds of thousands of years cannot be fully proved, it cannot entirely exclude a role for God. However, the Pope has not yet endorsed the views of creationism or intelligent design about life's origins.
- Ultimately, the rational and methodical approach of science cannot answer all our questions, which is why some people turn towards philosophy or theology or faith, or to the belief that God created the conditions which led to evolution or that a 'creative force' was ultimately responsible for the universe.

Practice questions

The following source and questions are typical of those that will be used in Section B of the AS Unit 2 examination paper.

Darwin's theory of evolution caused a considerable stir. It showed that science, and scientific methods, had the potential to explain things which previously had puzzled many people. It also shocked many people and challenged the thoughts and beliefs of people in Victorian society.

Yet, the theory of evolution has stood the test of time and scientists recognise that the work of Charles Darwin involved careful research and scientific methods, which made evolution an essential part of science teaching. Creationism and intelligent design are interesting theories but they rely more on faith and belief than methods that can be recognised as scientific.

Questions

- (1) For what reasons is Darwin's theory of evolution important in helping to explain the origins of life?** (17 marks)
 - (2) Discuss the view that creationism and intelligent design should be included as part of a science programme teaching about the origins of life.** (18 marks)
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