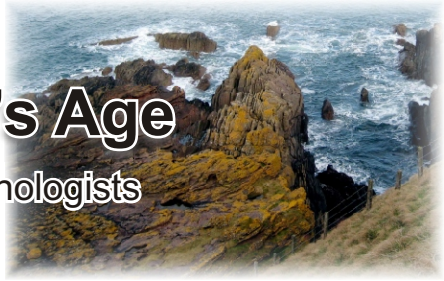
Understanding Earth's Age

Early Efforts by Naturalists and Chronologists



Advances in science are too often wrongly portrayed as the work of one person or a few individuals battling in the name of modern science against the darkness of ignorance and narrow-minded religion. How scientific understanding changes, as illustrated in early attempts to understand the Earth's age, debunks the commonplace "science versus religion" perception. This historical episode also illustrates that many individuals, over long periods of time and in strange ways, contributed to our current knowledge of the Earth's age. Examining the evidence and arguments put forward for the Earth's age will help you better understand how science works and the important science idea that the Earth is very old.

In the Western world, the earliest known efforts to determine the Earth's age came from people who, by modern standards, would not be considered 'geologists'. Around 350 BC, the Greek philosopher Aristotle suggested that the Earth and the universe were eternal – they had always existed and would forever exist. Jewish and Christian philosophy, on the other hand, argued that the Earth was created, and this view became widely held in the Western world. Many scholars were unconcerned with these speculations and were simply content to say the Earth was old – on the scale of a few thousand years. Given that at that time in history few people lived beyond fifty years, several thousand years seemed like a very long time. The disinterest in pursuing serious study of the Earth's age was illustrated by the lack of activity in this area among those we today would call "scientists", or among theologians.

Beginning about 1650, interest in the age of the Earth was rekindled, but for different reasons. This was the time of the Renaissance and the Reformation throughout Europe. Theologians and other scholars increasingly retranslated Biblical, Greek, and other texts. In addition to correcting bad translations, some scholars began to raise questions about some Biblical stories such as the Genesis account of creation and Noah's Flood. At this same time, people of all faiths and nationalities traveled – mostly across Europe – to better understand the world beneath their feet. Trading ships also returned from the Americas and Asia bringing exotic news reports. As humans scrutinized texts and explored the Earth in new ways, some interpreted the evidence as supporting a young Earth, while others put forth evidence suggesting the Earth was undeniably old.

One approach to understanding the Earth's age was to analyze chronologies found in texts that included, but were not limited to, Biblical scripture. This approach entailed estimating the lifetimes of historical figures and then placing them in order according to ancestry. Using this approach with the Bible had its limitations as much of it is simply a genealogical list of who begat whom. So chronologists turned to other records of mankind's existence, such as secular books and royal lineages. Reports from those having traveled to many parts of the world posed problems to the chronologies. The Chinese and Egyptians seemed to have much richer, longer histories than those of the Europeans. Lack of reliable records frustrated chronologists. Like all researchers, they had to make a judgment regarding the veracity of old and new information. They decided that this conflicting new evidence was unreliable and dismissed it, trusting their own written records instead.

Overall, chronology is a good example because it illustrates how inquiry of the natural world must be considered within the time frame it occurred and the prevailing culture. In the late 1600s, chronology drew respect for its rigorous collection of data and precise conclusions. In this sense, it possessed characteristics that 'modern' science values. Today, chronologists' efforts to understand the age of the Earth are often unfairly ridiculed. This is because some modern Creationists, in declaring James Ussher's date of October 23, 4004 BC to be the exact day of creation, have distorted the historical context in which those chronologists worked. That the chronologists did not force the Earth to be young is important for understanding the context of early work regarding the age of the Earth. The dominant culture already told chronologists that the Earth was young. They simply found a method to defend their culture's viewpoint.

A second approach to understanding the Earth's age, which came to be known as naturalism, reflected a new way of thinking about and investigating the natural world. This new way of thinking emerged over a long period of time and was influenced by many individuals. Because of the significance this emerging new way of thinking would have for science and all of society, this period of time (circa 1550 to 1730) is often called the Scientific Revolution. Astronomers like Copernicus argued that the sun should be at the center of the solar system. Doctors like William

Photo image of Hutton's Unconformity at Siccar Point, Scotland. Photo by Dave Souza.

Harvey argued for the circulation of blood in the human body. And physicists like Isaac Newton argued that the world should be understood through the interaction of forces and matter. The whole Newtonian system put forth two very important considerations for geologists: (1) the world should be explained in terms of natural events and not through supernatural intervention; and (2) the history of the Earth might not coincide with the history of humans. The idea that the Earth may have existed prior to humans populating its surface was very unsettling to seventeenth century scholars.

This complex and changing cultural backdrop is the context in which the first 'true' geologists (using today's standards) worked. Skepticism regarding using chronology to date the Earth had always existed. Those who opposed that approach now looked to evidence the chronologists had dismissed – the natural world. A new class of 'naturalists' argued that investigating the rocks and oceans were the best way to understand the Earth's history. But both the former and emerging new ways of thinking influenced their approaches to understanding the age of the Earth and the judgments they made regarding evidence.

These naturalists were gentlemen of 'proper' society, spending their leisure time enthusiastically inspecting the nooks and crannies of the Earth. Erasmus Darwin, Charles Darwin's grandfather, was known for climbing into the gullies and cracks of the English countryside in Derbyshire wearing his powdered wig, breeches, and topcoat. In 1787 the Frenchman Horace-Bénédict de Saussure led a team of men to the top of Mount Blanc, the highest point in the Alps, carrying mercury barometers and other equipment to test the air. Perhaps most important to understanding the age of the Earth, naturalists like Nicolas Steno studied strata and put forward the idea that the layers had been laid in order of the oldest at the bottom and most recent on the top. Embedded in these layers, Steno and others noticed preserved shapes of animal bones that nobody had ever seen before – fossils. This discovery would drive a whole new generation of naturalists to study the Earth's age to explain how the fossils got there.

1. Those who are investigating the natural world at this time have either the personal financial resources or the financial support from others to conduct their work. The word "scholar" comes from the Latin word "scholee" which means "leisure time". Today we hardly think of conducting scholarly work as "leisure". Why do you suppose that in the past, leisure time was associated with doing science and other forms of scholarship?

Determining the age of the Earth was also necessarily tied to developing an explanation that would account for how physical processes work to shape the Earth over time. Two approaches existed for developing a 'theory' of the Earth. One was to use Biblical events to explain a short timescale, and the other was to use natural events to predict a long time scale. In some cases the short timescale is associated with catastrophism, the idea that massive earthquakes, floods, and other events unlike those experienced today shaped the Earth. The longer timescale is associated with uniformitarianism. This explanation of the Earth claimed that forces presently acting on the Earth are the same as those that have acted in the past. Both approaches had their proponents within the scientific community, and both made reference to evidence of the natural world to support their thinking. The work of Jean-André de Luc and James Hutton illustrates these two approaches, but they are only two of the many individuals in both camps.

Jean-André de Luc was born in Geneva, Switzerland, and would later move to England and travel most of Europe. He was the first to use the word 'geology.' He was adept with tools and made the portable barometer used by Saussure in the Alps. While not adhering to a literal interpretation of the Bible, he wanted to explain the world in accordance with Scripture. Pointing to a set of marine fossils he found in the Swiss highlands, he called this the "apple of discord between [scientific scholars]." How could aquatic life be fossilized 7,000 feet above sea level in a land-locked region? Around 1780, the best explanation, he thought, was that at one point, the Earth had been entirely flooded. Very gradually, the water levels lessened and at the same time, the current continents on which naturalists now walked had risen from the bottom of the ocean. After a couple thousand years, the world would look like it does now and humans would populate its surface. De Luc didn't think Noah fit all of the world's creatures into the ark, but he certainly thought a very recent catastrophic flood shaped the world's landmass.

Jean-André de Luc

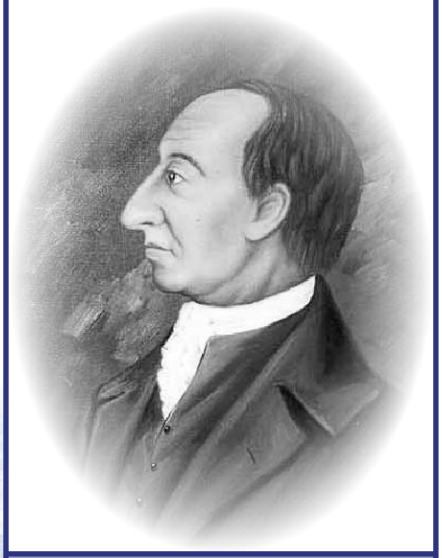
De Luc was just one of many scientists who tried to link scientific ideas to biblical history. Almost 100 years earlier, Thomas Burnet had written *The Sacred Theory of the Earth* using Scriptures as the starting point and trying to weave Newton's laws into his theory of the Earth's evolution. As Burnet's friend and colleague, Isaac Newton had assisted with and endorsed Burnet's book.

Note that De Luc and other scientists are straddling two worlds – one trying to understand the natural world in terms of naturalism, the other trying to understand the natural world in terms of biblical literalism.

De Luc wasn't alone in his arguments, but he was original in his methods. Unlike other scholars, he wanted his work to be understood by regular people unfamiliar with geology. He presented arguments for and against the Biblical account of Genesis, remarking that his new 'geological' method illuminated the full meaning of Scripture without contradicting it. However, he shied away from explaining the origin of the Earth. Noting the oldest rocks, or the "Primary" rocks, had no fossils, he turned to the "Secondary" rocks of more recent origin. He interpreted this to mean that at one time animals and vegetation unlike those seen in modern times populated the Earth. In the late 1700s, though, geologists had yet to find human fossils. De Luc and other naturalists interpreted this evidence to mean that the Earth existed *before* humans walked its surface. If so, then the age of humans was very recent.

About the same time, across the English Channel in Britain, James Hutton also traveled the countryside looking at exposed strata. Hutton is often called the 'father of geology,' but that does a gross injustice to the many other individuals working to understand the Earth. At the same time Hutton traversed Britain, countless other naturalists traveled the world. In many cases, they were like Erasmus Darwin, hunting minerals to be used for industry. In other cases they were like de Luc, trying to explain the Earth. In some recent histories, Hutton is portrayed as the noble scientist who fought the tyrannical grasp of religion. This is far from the truth.

Hutton was most well known for his 1795 book, *Theory of the Earth*, which argued for a near eternal world that had "no vestige of a beginning, no prospect of an end." As a background to this scientific proposition, Hutton should be seen as a man of his time. Trained as a doctor and familiar with the new ways of thinking about the natural world, he accepted the Newtonian explanations of gravity, light, and heat. He agreed that these were the forces that conducted nature and caused the seasons and other natural phenomena. He was also a deist, a new religious expression at the time, which meant that he believed God created and designed the world in a nearly mechanical way, such that after creation God never needed to intervene. The Newtonian laws, then, commanded over a land with was set up for human life, or as Hutton said, "We are thus bountifully provided with the necessities of life; we are supplied with things conducive to the growth and preservation of our animal nature, and with fit subjects to employ and nourish our intellectual powers."



James Hutton

Hutton's friends included fellow scholars and members of the Scottish Enlightenment who provided an environment that nurtured progressive ideas. Among the influential figures in the Scottish Enlightenment were intellectual icons such as David Hume (philosopher), Adam Smith (*The Wealth of Nations),* Joseph Black (discoverer of carbon dioxide), and James Watt (inventor of the steam engine). Hutton counted all of these men among his friends, but Joseph Black, with whom he shared a love of chemistry, was his closest friend. Hutton and Black brought their formidable grasp of chemistry to bear on the geological problems that Hutton was considering.

2. Consider how scientist's many associations likely influence and nurture their thinking. Many people dislike the thought of a science career, seeing it as a solitary undertaking. How does this story illustrate that science is a social endeavor?

Hutton traveled extensively, observing exposed rocks and strata found in quarries and cliffs. After a trip in 1786 to southwestern Scotland to Galloway, he wrote, "…here we found the granite interjected among the strata, in descending among them like a mineral vein, and terminating in a thread where it could penetrate no farther…[this] will convince the most skeptical with regard to this doctrine of the transfusion of granite."

The most popular story of Hutton is his trip in 1788 to Siccar Point on the east coast of Scotland. As he looked up

at the cliff face, he saw an 'unconformity' in the rocks. At the bottom of the cliff was gray micaceous greywacke. However, instead of lying horizontal, as they were accustomed to seeing in quarry walls, the beds were standing straight up. Above this layer was a nondescript jumble of large fragments of the greywacke, in a layer perhaps two feet high. Above that was another large exposure of layered rocks, this time lying horizontally and red in color.

Hutton explained what they were looking at to his companions. This unconformity, he said, demonstrated the cyclical process of nature. The greywacke that was standing vertically at the bottom of the cliff face had originally been laid down as horizontal deposits, which, he explained, was the only way sediments formed. After an enormous amount of time and the application of subterranean heat, they were transformed into rock. Then, the intensity of the heat was such that it caused the horizontal strata to buckle and fold and rise above sea level, resulting in the vertical formation that they were seeing. The tops of the buckled rocks immediately began eroding and after a time, the land was once again submerged under water. The jumble of fragmented greywacke that overlay the top of the buckled rocks was formed in the early stages of submersion, when waves crashed onto the shore. After the buckled rocks were once again submerged deeply under water, new sediments started piling on top of them. This time, the strata were formed from red-colored grains from different rocks on the Earth's surface. Subterranean heat and pressure once again acted to form the sediment into rocks and raised it above sea level again, but this time with less force, since the strata didn't buckle, but remained horizontal. He knew this idea to be similar to volcanoes, which he saw to be a sort of natural 'safety-valve' for the Earth. When pressure got too high, volcanoes released magma, moving interior matter to the Earth's surface.

Through these cycles, Hutton, a deist looking for a natural explanation, reasoned how the Earth regulated and preserved itself over time. Knowing that human history failed to record any drastic erosion, he argued that the processes must take place over a very long time, indescribable to humans. This indefinite timescale, practically an eternity, drew cheers and criticism, but then so did every other theory of the Earth. Hutton's main contribution to the history of geology at Siccar Point was to propose that very small changes happened over a very long time, which would become the backbone of the uniformitarian argument. Much later, Hutton's associate John Playfair would remark of their trip to the Scottish coast:We felt ourselves necessarily carried back to the time when the [sedimentary rock] on which we stood was yet at the bottom of the sea, and when the sandstone before us was only beginning to be deposited in the shape of sand or mud, from the waters of a superincumbent ocean. An epoch still more remote presented itself, when even the most ancient of the rocks instead of standing upright in vertical beds, lay in horizontal planes at the bottom of the sea, and was not yet disturbed by that immeasurable force which has burst asunder the solid pavement of the globe. Revolutions still more remote appeared in the distance of this extraordinary perspective. The mind seemed to grow giddy by looking so far into the abyss of time.

3. Many textbooks and teachers will talk about what data *shows* or what data *tells us*. How does Hutton's and other scientists' need to convince others of the meaning of observations illustrate that data doesn't *show* or *tell* scientists what to think?

The early theories of the Earth's age depended on many individuals of many beliefs from many countries. Of these early geologists, Hutton is today often seen as the 'winner'. However, during his career he often faired little better than other naturalists in defending his ideas of the Earth. While he made significant contributions to our understanding of the Earth, science textbooks typically give him excessive credit for today's accepted theory of the Earth. This episode in the history of science should be remembered as a time when very different kinds of science battled for acceptance. Each group gathered evidence and argued, using their own methods, for their particular conclusions. Understanding the Earth's age, like the development of all scientific ideas, was influenced by social factors and clearly required the talents and efforts of more than one person.

4. How does this story illustrate that efforts to understand the age of the Earth should not be depicted as science versus religion?

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