CAN ORGANISMS CHANGE?

Stenson, Buffon, Lamarck, and Cuvier

The Fossil Dilemma

Most human cultures have a creation story that tells not only how the earth came into being, but more importantly, why the culture that created the story is at the center of all creation and is superior to others.

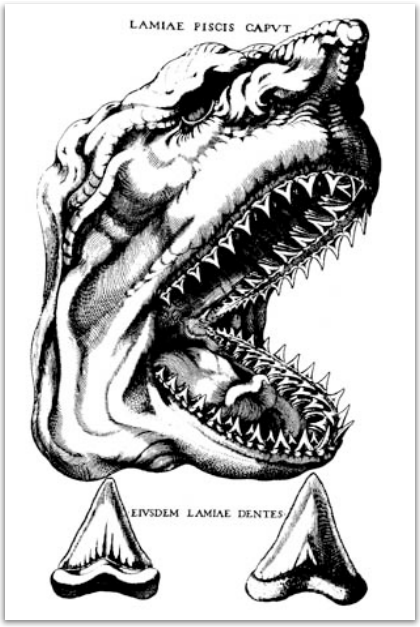




In Japan, creation stories tell of a great chaos, out of which rose the Plain of High Heaven, which gave birth to the first deities, who in turn created the world. The Navajo of North America tell of a series of four worlds through which their ancestors traveled to get to this world. In the Western world, the Greeks told of a great black bird, Nyx, that laid an egg, from which hatched the god Eros, and the shells of which became the earth and sky. The Judaeo-Christian Bible contains several accounts of the creation of the world by an all-powerful deity whose word made the earth and all living things. Implicit in this account is the idea that organisms, once created, have not changed. Tying all of these stories together is the belief in some deity or other agent of change outside the natural world that can, through means not conforming to physical laws, change the physical world.

In the 17th century, the Judeo-Christian accounts of creation were accepted as truth in Europe and much of the Middle East. This century is important because if any date must be chosen as the date on which the first questions leading toward a naturalistic explanation of the history of the world were asked, it must be 1666.

Niels Stensen (known to historians as Steno) was a Danish anatomist who was studying in Florence in 1666. That year, two fishermen caught a giant shark not far from Florence. Sharks of that size were rare in Italian waters, and so unusual a creature demanded special attention. A local nobleman ordered that the shark be brought to Steno, who dissected it. Steno had never seen shark's teeth before, but he was familiar with novel stones called "tongue stones," and was struck by the resemblance between the two.



Steno make a leap in logic than no one before him had made. At the time, naturalists were just forming an idea that matter was made of small particles that they called "corpuscles," the equivalent of what we call molecules today. Steno proposed that the "tongue stones" were the teeth of once-living sharks. The "corpuscles" of the former teeth, he proposed, had over a period of time been replaced with "corpuscles" of stone.

Figured Stones

Steno, like many of his contemporaries, was familiar with "figured stones," those stones pulled from the earth that appeared to have pictures in them. How the pictures got there no one knew. Some naturalists thought that they grew in the rock just as crystals grew, possibly from seeds or eggs embedded in the earth. While such an hypothesis sounds fanciful today, the known physical laws at Stenson's time did not rule such an hypothesis out. Other naturalists, however, thought that figured stones could be the remains of one-living things. After all, they knew that dead leaves and other objects could leave impressions in mud, and if the mud dried, the impressions remained. The bones of dead animals could remain in the earth for years, even centuries. Would they not remain if the soil were compressed into rock?

Leonardo da Vinci was one early naturalist who examined fossils, and his conclusions were remarkably modern. da Vinci observed clam fossils high in the Swiss Alps, and noted that where he found fossils at a particular elevation on one side of a canyon, he would find similar fossils on the other side. The shells he found were so like clams he could find in the sea, that da Vinci was convinced they were the remains of once-living clams. The shells were still articulated — that is, the two halves of the shell were closed, a feature he had observed in living clams. Dead clams fall open as the muscles relax after death. From this he concluded that the clams had been covered by silt while still alive. da Vinci concluded that these fossil strata were remains of an old sea floor that had, through some process unknown at the time, been elevated. Later erosion by fast-moving water or slow-moving glaciers cut through the strata, leaving the fossils high and dry on the canyon walls.

These naturalists drew some insightful conclusions directly from observed data. Not all naturalists at the time valued field work, and it wasn't uncommon for scientists to make "discoveries" based on pure logic and reasoning. Western thought at the time, as the Age of Enlightenment approached, was that if God made the universe and God was the perfect embodiment of rationality, then the universe itself must be rational. Therefore a rational

thinker could reason his way to the truth. The unfortunate tale of Johann Beringer and the figured stones of Würtzburg illustrates the shortcomings of this philosophy.

Beringer was a professor of medicine at Würtzburg, and lectured often on fossils. He believed that while some might be the remains of once-living organisms, most were the handiwork of God. Beringer was known for his arrogance, which may have been the impetus for one of the best-known fossil hoaxes in history.

In 1726, Beringer published *Lithographia Wirceburgensis,* a catalog of fossils he and his assistants had unearthed near his home. In the introduction to his book he wrote, "God, the founder of Nature, would fill our minds with His praises and perfections radiating from these wondrous effects, so that, when forgetful men grow silent, these mute stones might speak with the eloquence of their figures."

However, inspection of the "figured stones" that Beringer studied and held as examples of God's personal handiwork bore obvious marks of a chisel. Many were crude figures of whole living organisms, some caught in the act of predation. Others were images of everyday objects, falling stars, or Hebrew letters.

It wasn't long before two of Beringer's professional critics, Ignatz Roderick and Georg von Eckart, came forward and admitted to carving the stones, planting them in the hills outside of Würtzburg, and leading Beringer to them. The admission nearly ruined Beringer's career, and the embarrassed doctor spent a considerable amount of his personal fortune buying back copies of his famed book.

Buffon

Georges-Louis le Clerck, Compte de Buffon (1707-1788) was a French naturalist working about the same time as Beringer. Like many naturalists at the time, Buffon was keenly interested in "figured stones" and their possible meaning. He was also interested in all of nature and living things — to the extent that when asked by the king of France to catalog the collections of plants and animals in the Royal Gardens, Buffon set about writing a complete catalog of everything that was known about the natural world. He completed 36 volumes of his *Histoire naturelle, générale et particulière* before his death.

Buffon, more than any other naturalist of his day, epitomizes the revolutionary change in thought that characterizes the Enlightenment. Yet Buffon was very much a man of his time, and that is reflected in the way he approached science.

Fossils, he believed, were indeed the remains of once-living creatures. The fact that some fossils bore resemblance to living creatures, yet held distinct differences, and some bore no resemblance at all to any known living creature, led Buffon to conclude that the species might not be not fixed after all, as Christian doctrine indicated. Could species actually change? Buffon believed that fossils showed they could indeed, and proposed the first Old Earth theory and the first theory of organic change put forth by naturalists.

Buffon proposed that the earth had once been a part of the sun, but a comet colliding with the sun caused a massive piece to break off. Eventually this piece cooled and became the earth. After it cooled, the earth became covered with oceans, which eventually receded, leaving marine fossils in areas that today are mountains. He estimated about 75,000 years were required for all of this to happen. While his proposition explained da Vinci's mountain fossils, the theory was supported only by Newtonian physics and Buffon's own logic.

Buffon went further to propose a theory of organic change to explain why organisms, if the fossil record were to be believed, appeared to change over time. Like most scientists of his day, Buffon believed that microorganisms could appear by spontaneous generation. Buffon proposed that all organisms were divided into natural families that look similar because they all have a similar internal plan (*moule interieúr*). Particles inside an organism shaped that organism to its environment. If an organism were moved to a different environment, the internal particles would be shaped differently to force the organism toward a shape that was better suited for that environment. A developing fetus, he believed, was especially, susceptible to this kind of influence. For example, Buffon noted that horses and zebras were both horse-like and belonged to the same natural family, and both were adapted to their native climates. If a herd of horses were moved from Europe to Africa, they would not be entirely suited to their new environment. All of the next generation of offspring would be influenced by the African environment and would look slightly more like zebras. Leave a herd of horses in Africa for several generations, Buffon proposed, and after several generations they would look just like zebras.

It was a daring proposition that flew in the face of the Christian doctrine that proclaimed that all species were fixed in the form they were given on the day of Creation. While the theory was logically sound, Buffon had very little direct evidence to support it. The theory won little support in France, and in England it was openly mocked. From Buffon's name, the word "buffoon" came into the English language.

Cuvier

Georges Cuvier (1769-1832), a naturalist in post-Revolutionary France, had been a student of Buffon. Cuvier was an anatomist who spent hours bent over specimens that he and his assistants dissected in great detail. Cuvier, like Buffon, was keenly interested in fossils, especially from an anatomical viewpoint. He was such a skilled anatomist that he could take a single tooth that anyone handed him from either a living animal or a fossil one and describe what sort of animal the tooth had come from.

Though Cuvier had studied under Buffon, he disagreed with Buffon's ideas of organic change. In Cuvier's views, organisms were perfectly formed for their habitat. As an anatomist he observed both internal and external structures that organisms used in survival. If any one of these were to change, Cuvier argued, the change would be fatal to the organism. He had only to point out the "monsters" that were occasionally born to humans and to farm animals (what we would call birth defects) to show that change and variation were bad things. However, Cuvier knew his anatomy by carefully dissecting single specimens. He was not a field naturalist, and little appreciation for the natural variation within species. However, he did agree with Buffon that classification of organisms should be non-hierarchical and based on natural features.

Cuvier agreed with Buffon on one other important point: extinction. The idea was anathema to Christian doctrine of the time, in which nature was viewed as one great hierarchy extending from the lowest microbes to the highest organism — humans — in one unbroken chain of being. Why would a rational deity create a great chain of being, then allow any of its members to go extinct? Yet time and again, naturalists uncovered fossils that appeared to be the remains of ancient organisms that had gone extinct. To explain this, Cuvier used the theory of Catastrophism. The earth, he said, underwent occasional great catastrophes that drove some species extinct. Those that survived moved into areas where other species had been wiped out. While this neatly explained the fossils found in the Paris basin where Cuvier worked, it did not explain why organisms seen today were not found in ancient strata. Cuvier's Catastrophism also implied catastrophes could be of an origin beyond the laws of physics — possibly of divine origin, though Cuvier, despite being a religious man, strove to separate his religious believes from his rigorous science.

Lamarck

Jean Baptiste Pierre Antoine de Monet de Lamarck (1744-1829) was another protégé of Buffon. While he had some interest in fossils, one of his biggest questions was where do we draw the line between species? What constitutes a species? Lamarck sided with Buffon on the issue of organic change, believing the things do an must change over time as their environments change or they risk going extinct. He disagreed with both Buffon and Cuvier regarding the classification of organisms, believing that there was a natural hierarchy, and it was his powerful belief in this hierarchy that influenced his theory of change, the first theory of Evolution.

It was Lamarck who first used the word "evolution" to refer to species changing over time. The word, with its implication of progress toward an ideal, fit his notions of what change was about. Like most naturalists of his day, Lamarck thought that microorganisms could appear spontaneously from nonliving material. In his evolutionary model, spontaneous generation provided the raw material for evolution.

Organisms, Lamarck argued, were engaged in a great struggle to climb the evolutionary ladder. Those at the bottom, the microbes, strove to become multicellular organisms. The lower organisms strove to be more complex higher organisms, and so on. Need drove change, as organisms developed the features they needed to survive. There would always be lower organisms, because spontaneous generation continued to supply new microbes to the system.

What actually caused change, in this model, was the inheritance of acquired characteristics. This idea was not Lamarck's own idea, though it has been widely attributed to him. In fact, most people at the time believed that characteristics developed during one's lifetime could be passed on to one's offspring. Everyone knew, for example, that a blacksmith's right warm was larger than his left arm, due to his constant use of that arm. The blacksmith's sons, who also practiced their father's trade, also had enlarged right arms. Lamarck thought that in nature the same mechanism would act on organisms. Large cats that ran after their prey would exercise their legs, and each generation of cats would be born with longer and longer legs. Conversely, salamanders that move into caves would slowly lose their eyes because sight was no longer needed.

Yet even in Lamarck's day, naturalists were beginning to question this assumption. They found that exercising sheep by running them around a pasture every day did not produce

longer legs in the lambs, even after several generations. The idea of organisms changing in response to a need sounded logical, and fit Romantic ideas of a beneficent Nature, but had little real-world data to back it up beyond observations of how organisms are today.

Lamarck's theory was not universally accepted, but it did cause naturalists to question whether species can in fact change over time. A coherent picture of evolutionary change would not appear however, until three new ideas came about: 1) a move away from the notion of a pre-determined plan for change, 2) a plausible mechanisms for change, and 3) the discovery that inheritance happens in predictable patterns.

Questions

1. Discuss Steno's observations on the shark and what inferences he drew about the "tongue stones." What alternate inferences did other naturalists make about "figured stones" at the time?

2. Consider the century in which Beringer lived, and views of fossils at the time. Why was he so quick to believe that the stones were real, and to accept a divine explanation?

3. In Beringer's book, he proposed a classification scheme, asked questions, proposed multiple hypotheses to explain the fossils, and invited discussion. Considering this, how did the quality of his work compare with that of his contemporaries, such as Buffon? How does the quality of his work compare with scientists today?

4. Science today relies on empirical evidence to support laws and theories. What was acceptable as evidence at the time that Buffon was working? How were views about evidence changing by the time Cuvier was working?

5. Lamarck strongly believed in a hierarchical ordering of nature, from "lower" to "higher." How might he have been influenced by the society in which he lived in forming this idea? Why might Cuvier's ideas have been different, even though they were colleagues?

6. Buffon, Cuvier, and Lamarck all published theories about organic change and extinction. Lamarck was the first to use the term "evolution" to describe organic change. Yet each of their theories fell in the 20th century as the science of genetics developed, while Darwin's ideas of natural selection were supported by genetics. What does this say about a) the tentativeness of scientific knowledge and b) the role of evidence in scientific progress?