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Philosophers like Lucretius and Pythagoras in ancient Rome and Greece produced revolutionary ideas connecting numbers and geometry to the natural world. This new age of philosophers did not bend with the gods, rather they questioned previous beliefs about the universe and tried to answer these questions using logic. They proposed that the entire universe could be explained with numbers. This was an innovative way of thinking for their time and they were correct. Modern day mathematics agrees with this way of thinking; nature and the universe can be studied using numbers and geometry. Fractal mathematics studies the pattern of small recurring shapes that combine into a larger complete structure. These patterns are found frequently throughout nature. For example, jagged coastlines can be simulated by drawing infinite summations of triangles (Modeling Nature with Fractals). Pythagoras (570-496) and Lucretius (94-56 BCE) accurately described the universe using numbers and geometry, and were among the first to explore fractal mathematics in nature.

Pythagoras was a Greek philosopher who studied philosophy and mathematics. He was the founder of the famous Pythagorean Theorem that described the relationship between the three sides of a right triangle. He took his

understanding of mathematics and applied it to philosophy, he believed that he could use math to explain the world he lived in. Pythagoras is quoted to say "numbers, as I have said, constitute the whole universe" (A Presocratics Reader 3.18.) Instead of blindly following the current dominating belief that the structure of the universe was controlled by the gods, Pythagoras boldly turned to mathematics for answers. He understood that the geometric relationships he studied were not a coincidence, instead they were the laws that governed the universe. Pythagoras understood that there was a deeper meaning to his geometric proofs and he was correct, as modern mathematics is used to describe nature frequently. For example, the structure of a tree follows fractal mathematics very closely. The trunk of the tree rises out of the ground and from the trunk, branches spread out, and then more smaller branches in succession this creates a pattern of small repetitions (Branching Fractals.) Pythagoras could have noticed these patterns in nature and come to the conclusion that they are not random and could be explained using numbers and math. Fractal patterns of repetition similar to this are found naturally in the world, proving that numbers are the constituents of the natural world just as Pythagoras predicted many years ago.

Lucretius lived past the era of presocratics, but his thinking was similar, as he also approached questions

logically as he sought to find the truth. Lucretius theorized that the universe is made up of atoms. These atoms are pure and have no color, in order to produce color and different materials they had to be arranged into shapes. In *On the Nature of Things* 2.784-785 Lucretius states that a simple triangle of atoms can be used to create other shapes "Nothing about assorted different triangles would impair their union's ability to form the outline of a square." Triangles are a building block, as they are the most basic shape that you can make in two dimensions. Any shape can be created by combining any number of triangles. Lucretius argued that anything in nature can be formed from shapes of atoms, including foods such as olive oil (2.851), or animals like ravens and swans (2.822). This implies that anything in nature can be formed from triangles. This idea is used in modern day mathematics to simulate realistic natural landscapes, including mountains and planets. They are formed using the same ideology that Lucretius theorized, an infinite number of small triangles are added together in order to form the desired shapes in the landscape. This is the basics of fractal mathematics, since nature follows fractal patterns often, these simulated landscapes appear to be extremely realistic (Modeling Nature with Fractals.) It is incredible that this modern method of simulating nature with math was first

explored thousands of years ago in ancient Rome by Lucretius.

These theories by Pythagoras and Lucretius were likely not accepted by the majority of the citizens in antiquity. The two philosophers were proposing revolutionary ideas that directly conflicted with the current teachings from the religious authority and state. Ancient citizens in antiquity were comfortable with the traditional idea that the gods created the world that they lived in and that nature bowed to the will of the gods. However, some open-minded ancient citizens must have realized the importance of their work, because it was preserved and we are able to enjoy it today. Pythagoras understood that numbers constitute the universe, this can be seen when describing fractal patterns in nature such as tree growth. Lucretius theorized that anything in nature can be created with triangles of atoms, the same way that modern math simulates natural landscapes. At first glance, nature seems chaotic and uncontrollable. But in reality, just as Pythagoras and Lucretius theorized, nature can be described by using math and geometry.

Bibliography

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