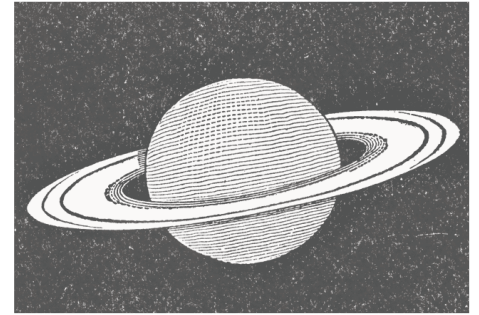


NATURALIST'S CORNER



Tycho Brahe and the Birth of Modern Science

In late August, NASA launched its newest space telescope, the Nancy Grace Roman Space Telescope. Nearly a million miles from Earth, this extraordinary observatory will survey the universe using 18 sensors capable of producing images at 300-megapixel resolution. Scientists hope it will reveal distant galaxies, and help us to both understand the mysterious forces shaping the universe and discover exoplanets in our own galaxy. It almost makes you wonder what humans are capable of knowing.

Now look back about 450 years. Imagine trying to understand the universe without a telescope. No Hubble. No computer. No digital cameras. No spacecraft. Just your eyes, some ingenious instruments, a notebook, and a remarkably dark sky. That was the world of Tycho Brahe. And although Brahe never looked through a telescope, his work helped create the scientific world that eventually made telescopes like the Roman Space Telescope possible.

Tycho Brahe was born in 1546 to a wealthy noble family in what is now southern Sweden. His family was part of the Danish aristocracy, and his future seemed predetermined. Like many young noblemen of the time, Tycho was expected to attend one of Europe's great universities and prepare for a career serving the Danish Crown. His uncle sent him away to study law and diplomacy. There was just one problem: Tycho became fascinated by the heavens.

In the sixteenth century, people believed that the movements of the planets and stars could influence events on Earth—and even human behavior. Brahe became fascinated by the possibility of predicting celestial movements. But science was not considered a noble pursuit for an aristocrat, so Tycho kept his astronomical interests largely to himself. By day, he was preparing for a respectable career. By night, he was looking up.

Tycho soon discovered something that would change the course of his life: The astronomical tables were wrong.

On August 21, 1560, he watched a solar eclipse that astronomers had predicted would occur either a day or a week away from the actual event. In 1563, Jupiter and Saturn came together in the sky, but once again the predictions were significantly off. Then came another failure. In 1566, Brahe used a lunar eclipse in an attempt to predict the death of an Ottoman sultan. Unfortunately, the sultan had already been dead for several weeks. The universe, it seemed, was refusing to cooperate with the experts. Brahe drew an important conclusion: If humans wanted to understand the heavens, they needed better observations and better measurements. He was about to become very good at both.

Later, in 1572, a brilliant new star appeared in the constellation. This was Cassiopeia. Today we know it was a supernova. But Brahe didn't have that vocabulary, or even the scientific framework, to explain what he was seeing. The dominant view of the universe, inherited from Aristotle and Ptolemy, held that the heavens were perfect, eternal, and unchanging. The stars were supposed to be fixed in their celestial spheres. Yet here was a new star. Something had changed. Brahe carefully measured its position and, remarkably, determined that it was farther away than the Moon. The heavens were not the unchanging realm people had assumed them to be. The universe had just broken one of the rules.

And Tycho Brahe was paying attention.

Brahe invited talented mathematicians, astronomers, and other scholars from across Northern Europe to work with him at Ven, the small island between mainland Sweden and Denmark on which he was establishing a research complex. There, Brahe built increasingly sophisticated instruments and had his students test them for accuracy. And then there was dinner. Brahe and his students regularly ate together, discussing their observations, comparing results, arguing over ideas, and figuring out how to improve their work. This was science as a team sport rather than the solitary pursuit of a lone genius. And sometimes even the best team discovered that the problem wasn't in the mathematics. It was the wind.

Ven was a windy place, and Brahe discovered that gusts could make his astronomical instruments wobble just enough to introduce errors into measurements taken at Uraniborg, his first observatory on Ven. So Brahe built a new observatory. This one was underground. Stjerneborg was designed to protect the instruments from the wind and provide a more stable environment for observations. It is a wonderfully Brahean solution to a research problem: If the wind is ruining your data, build your observatory underground.

Brahe and his students became the last great astronomers to map the heavens without the aid of a telescope. Their observations were astonishingly precise. But Brahe's greatest contribution may not have been a particular observation or even a particular theory about the universe. His real legacy was the way he did science. At Uraniborg, Brahe helped establish several ideas that now seem fundamental to scientific research. Science should be collaborative. Ideas should be tested. Instruments should be calibrated. Observations must be repeated. And perhaps most importantly, error is inherent to measurement.

Brahe openly discussed the limitations of his instruments and the conditions under which his observations were made. When he published his work, he didn't simply announce what he believed to be true. He also discussed what he could not know with certainty. That may sound obvious today, but it was a profound change in the way people thought about knowledge. Science was becoming less about possessing the right answer and more about figuring out how much confidence we should place in an answer.

After Brahe's death, his assistant and former student Johannes Kepler gained access to the enormous collection of observations made at Uraniborg. Kepler used those measurements to discover the mathematical laws describing planetary motion. Those laws would later provide Isaac Newton with crucial evidence for his theory of gravity. And Newton's work would eventually become part of the intellectual foundation upon which modern astronomy was built.

From Brahe's island observatory to Kepler's equations, from Newton's gravity to modern telescopes, satellites, and spacecraft, there is a long chain of curiosity connecting them all. Which brings us back to the Nancy Grace Roman Space Telescope. Today, we can place an observatory nearly a million miles from Earth and ask it to photograph galaxies billions of light-years away. Tycho Brahe had few tools at his disposal. He had no telescope. He had no computer. He had no spacecraft. He simply stood beneath the night sky, carefully measured what he saw, questioned existing explanations, invited others to test his work, and admitted when his instruments had limits. That may be one of the most important lessons Brahe left us. Before science could reach the stars, someone first had to learn how to measure them.

~Tom Condon



Tycho Brahe



Johannes Kepler