THE ANTIKYTHERA MECHANISM

It's been variously described as an ancient Greek astronomical calculator, an astonishingly advanced hand-powered orrery, the world's first analogue computer, a cultural treasure, and the most important maritime shipwreck discovery of all time. But whatever words you choose to describe it, the Antikythera Mechanism is truly remarkable.

In 1900, divers went to the seabed in heavy canvas suits wearing helmets of copper and brass. One such diver, Elias Stadiatis from Symi in the Mediterranean, was searching for natural sponges when he found a shipwreck near the island of Antikythera, located between Greece and Crete. That wreck contained marble and bronze sculptures from ancient Greece, plus a chunk of something that didn't look like much … until it broke open a year later at the National Archaeological Museum in Athens to reveal bronze gearwheels that at the time seemed deeply anachronistic.

We can accurately date the shipwreck the Mechanism was found in to 70-60 BCE. The Mechanism is obviously older, and estimates of its construction date range from 205 BCE to 87 BCE, with the most likely range being 150-100 BCE. Which is a *long* time ago. According to twentieth century conventional wisdom, such fine cogs, gears and dials (some with millimeter-sized teeth) should not have existed until many hundreds of years after the wreck went down.

It's not quite the earliest example of gears. Those honors go to a relatively straightforward Byzantine geared sundial dating from the 6th century BCE, and some iron cogs from Zhou dynasty China in the 4th century BCE. But the Mechanism is far and away the most intricate and complex geared calendrical device ever discovered from the ancient world. Such complexity would not be recreated for a millennium and a half, with the astronomical clocks built in the 14th century CE.

The discovery of the Antikythera Mechanism threw all our assumptions about ancient technology out the window. Over a hundred years after its discovery we're still adjusting ourselves to this tectonic shift in our understanding, and learning more and more about this fascinating machine.

So, what is the Antikythera Mechanism, and what have we learned about it lately?

That original single glob containing the Mechanism has now been divided into 82 fragments for analysis and preservation. Among those fragments are 30 corroded bronze gearwheels, some of them tiny. What has survived represents perhaps a third of its original content. A huge amount of work has gone into analyzing, reconstructing, and modeling the Mechanism, trying to recover what it originally looked like, and how it operated.

That hasn't been easy. But we now know that in its original form, the Antikythera Mechanism was a rectangular box of bronze and wood, maybe 34cm by 18cm by 9cm, containing dozens of small interlocking gears that moved pointers and concentric rings. Spheres and beads marked the positions of the various celestial bodies. It had a main drive wheel on the front, and two large dials on the back, from which a variety of astronomical and astrological quantities could be read out.

Easy enough to summarize, but the above is the culmination of decades of study by Albert Rehm, Derek J. de Solla Price, Charalambos Karakalos, Michael Wright, their collaborators and team members, and many others, and it was only very recently that the final pieces of the puzzle fell into place. This was

groundbreaking work published in March 2021 by Tony Freeth and his group at University College London, that advanced a new analysis of the gearing on the front of the mechanism that finally makes all the gears and fragments fit consistently, incorporating an elaborate series of calculations describing how the gearing of the wheels within the box worked their "magic" to produce accurate astronomical answers. The Freeth team achieved this using microfocus X-ray computed tomography (X-ray CT); the same group had published a previous paper in 2008 laying out the math and tech underlying the back of the Mechanism, and their most recent paper bookended this by finalizing the likely configuration of the front. In the process, they realized that the presumably-Greek creators of the Mechanism had calculated greatly improved period relations for Venus and Saturn in particular, when compared with those used by the Babylonians which underlie many of the Mechanism's math. The new relations required trains of up to seven gears to calculate, deep within the Mechanism. Amazing.

The calculations that could be performed using the frontal Cosmos Display and the intricate sets of gearing inside this relatively small machine include the abilities to predict, for any given day in the past or future of the machine's era: the ecliptic longitudes of the Moon, Sun, and the five planets then known (Mercury, Venus, Mars, Jupiter, Saturn); the phases of the Moon; the synodic phases of the planets; the excluded days of the Metonic Calendar (a bit obscure, this one—don't ask); the heliacal rising and setting times of significant stars, and even the cycle of the Olympic Games.

Even with twenty-first century technology and math, the construction of such a machine from first principles in such a compact form, without microchips or even electricity, would be a daunting task. That the Mechanism was constructed using only hand tools, over two thousand years ago, has forced us rethink our ideas of the ancient world.

The Mechanism is often presented as a one-of-a-kind object, because, well … it's the only one we have physical evidence of. But it obviously wasn't the only object of its type. It defies common sense that there could have been only one exceptionally advanced mechanism, with no precursors, no prototypes, no other similar machines. But objects made of metal tend not to survive in the historical record—they get melted down, their metals reused. The bronze statues found in the Antikythera wreck are also relatively rare. It takes an unusual circumstance, like a shipwreck, for such items to be preserved.

How many other such Mechanisms were there, now lost to history?

What other different *types* of Mechanisms might there have been?

Cicero (106-43 BCE) in his De Re Publica refers to a "Sicilian mechanism" made by Archimedes (c.287-212 BCE), "on which were delineated the motions of the sun and those five stars which are called wanderers [i.e. the five planets] … Archimedes … had thought out a way to represent … by a single device for turning the globe those various divergent movements with their different rates of speed."

Was this a precursor to the Antikythera Mechanism? Seems likely. And there are other references in Greek literature. Pappos of Alexandria states that Archimedes wrote a whole treatise (now lost) on how to construct orreries. Romans Lactantius and Claudian refer to them too. Other accounts may indicate that such mechanisms were also in use in the Byzantine and Arab worlds.

So, your takeaways: the Antikythera Mechanism is really cool. The math and metalworking skills required to construct it were intense. The idea that the heavens are orderly and mechanical enough to be predicted is itself important, so many centuries prior to Newton. Our understanding of what the classical world was capable of has definitely been torqued around (pun intended) by the Mechanism's existence. We now have to accept the reality that people had a much higher degree of technical capability, far earlier than we might have expected.

And clearly it's not too far out in left field to speculate that cultures other than the Greeks might have also had more complex mechanisms and cosmological understanding than we give them credit for.

In the Antikythera Mechanism we have a couple of intriguing Turning Points—both in terms of the sophistication needed to create it in the first place, and in the reverse Turning Point where that knowledge and expertise was lost. What if science and technology had continued on a steady upward path from the decades where skilled ancient artificers collaborated to create devices like the Antikythera Mechanism?

How far might civilization, culture, and technology have advanced by, say, a thousand years later, around 800 AD? Let alone two millennia …

Impossible to say, of course. But mind-boggling to consider.

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