Dawn of Science

19. Measuring the Heavens

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Keywords
Huygens, pendulum clock, Saturn's rings, Titan, Cassini.

His improved telescope gave Huygens a better vision of the sky, but his ideas about light lay buried for a century.

After the Copernican Revolution, physics – or 'natural philosophy' as it was then called – was taking rapid strides with contributions from Descartes, Torricelli, Boyle, Pascal and many others. One of the important contributions to physics and astronomy in the later half of the 17th century came from Christian Huygens (1629–1695) from the Netherlands. Unfortunately, the importance of his work was overshadowed by the towering dominance of Newton's work.

Born in a wealthy family in The Hague, Huygens had an excellent education. Among his father's friends were several intellectuals of Europe with whom he corresponded regularly. In 1645, Huygens went to the University of Leiden where he studied law and mathematics. His first breakthrough came in 1655. While helping his brother to make a telescope, Huygens stumbled upon a new and better method of grinding lenses, which enabled him to build telescopes with much higher resolutions. He promptly built an astronomical telescope, about 23 feet (7 metres) long, and started scanning the sky, coming up with several important discoveries.

The first was a huge cloud of dust and gas in the constellation of Orion, which we now call the Orion nebula. Huygens also found a satellite of Saturn, which was as large as any of the Jovian satellites, and named it 'Titan'. (In Greek mythology, Saturn is the leader of a group of gods called the Titans.) With this discovery, there were now an equal number of planets and satellites in the solar system (six each). Huygens fell into the natural trap and declared to the world that no more satellites or planets remained to be discovered; within his lifetime, four more

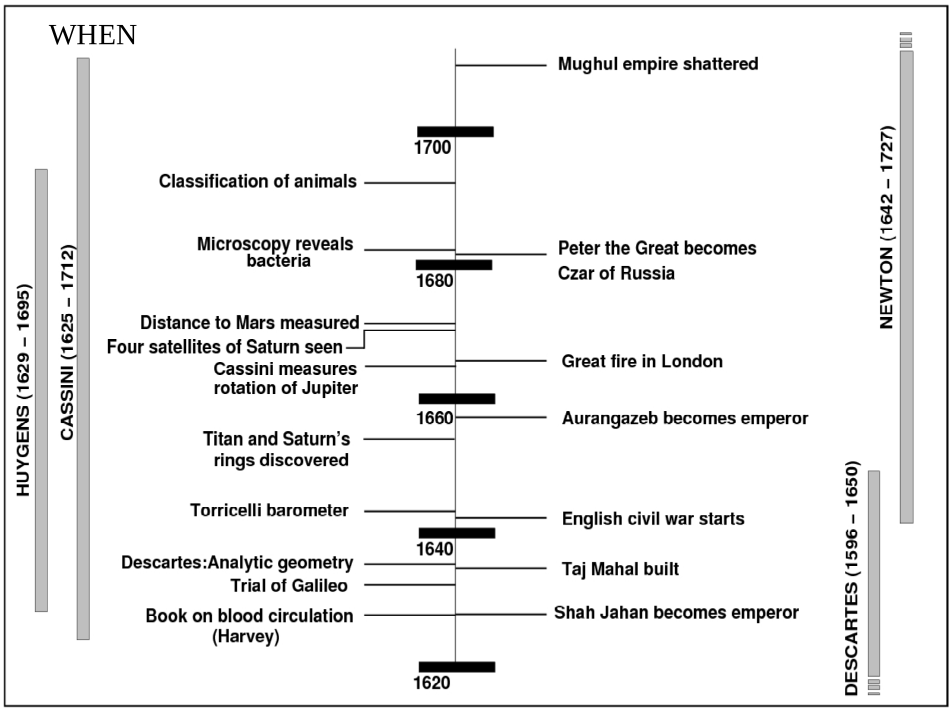


Figure 1.

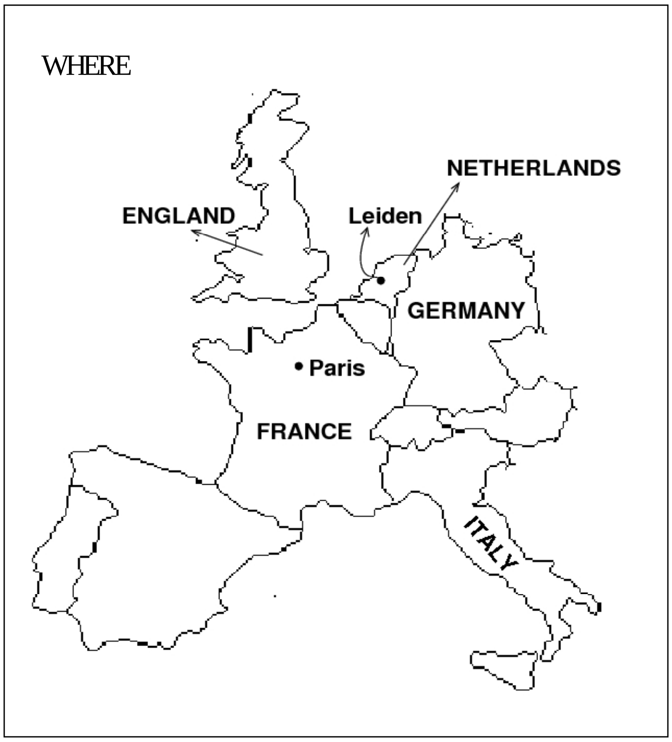
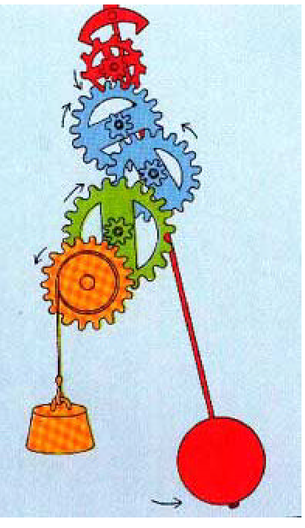


Figure 2.

Figure 3. Christian Huygens.
Courtesy:
http://en.wikipedia.org/wiki/Christiaan_Huygens

Figure 4. Huygens pendulum clock.
Courtesy:
http://www.timekeepingsite.org/clock.htm



satellites were seen! Huygens' telescope also showed that Saturn was surrounded by a thin ring, which did not touch the planet. These rings were something unique and attracted quite a lot of attention.

Huygens also tried to make quantitative estimates in several areas of astronomy. He was the first to make a serious effort to determine the distances to the stars. Assuming that the brightest star Sirius was as bright as the Sun, he estimated its distance to be 2.5 trillion miles. (The actual distance turned out to be 20 times larger because Sirius is actually much brighter than the Sun. One shouldn't blame Huygens for this. Errors of similar nature are, for similar reasons, routinely made in astronomy!) In the course of making these quantitative measurements, Huygens realised the need for accurate measuring devices. He developed two such instruments. The first was a micrometer with which he could measure angular separations as small as a few arc-seconds. The second was a pendulum clock, which brought Huygens fame and glory.

The best clocks available in Huygens' days were those designed in the Middle Ages. These were complicated mechanical devices powered by falling weights. Though such apparatus were adequate to produce fancy-looking decorative pieces for royal courts, their accuracy was limited to about a fraction of an hour; this made them useless for scientific studies. To build a more accurate clock, one needed a device which moved with a constant period. It was known from Galileo's time that a pendulum did this fairly accurately. All that one needed to do was to connect the pendulum to suitable gear wheels and attach falling weights to supply the energy lost due to friction. This was basically what Huygens did and the first 'grandfather clock' was born. To improve accuracy, Huygens added one crucial refinement. He knew that the pendulum kept a constant period only approximately, so he adjusted the movement in such a way that the period would remain exactly constant. And his clock was accurate to a fraction of a minute.

The pendulum clock spread Huygens's name throughout Europe. He was elected a member of the Royal Society in 1663 and was invited to the court of Louis XIV in Paris in 1666. He did spend some time in Paris but returned to the Netherlands in 1681 when Louis XIV started promulgating ordinances against Protestants (Huygens was a Protestant).

Figure 4. Grandfather clock. Courtesy: http://en.wikipedia.org/wiki/Longcase_clock

Yet, Huygens's most significant contribution did not get any recognition during his lifetime. This related to the propagation of light. Huygens firmly believed that the propagation of light could be understood as a wave phenomenon. But this idea violently conflicted with the prevailing notion that light rays were corpuscular (that is, made of tiny particles) in nature. The strongest evidence against Huygens's model came from everyday experience – that light always travelled in a straight line. This was contrasted with typical wave propagation like that of sound; while sound waves can 'bend around' obstacles, light cannot. (That is why you can hear someone around a bend even when you can't see that person.) Huygens showed that there were indeed conditions under which light may appear to travel in a straight line even though it was fundamentally a wave. Unfortunately, no one took him seriously (partly because of the dominating influence of Newton's concepts which assumed that light was made up of particles). And so Huygens' ideas about light lay buried for another century.

Meanwhile, astronomical discoveries similar to those of Huygens were also made by the French astronomer Giovanni Cassini (1625–1712) around the same time. Cassini began with a detailed study of Jupiter's moons and measured Jupiter's period of rotation. He then turned to Saturn and discovered four new satellites which were named Lapetus, Rhea, Dione and Tethys. In this process, he proved Huygens' conjecture of 'equal number of satellites and planets' wrong· He also showed that the ring around Saturn was a double one; the gap between the rings is still called the Cassini division.

Cassini's most valuable contribution was probably the measurement of the distance to Mars.

Figure 5. Saturn.
Courtesy:
http://en.wikipedia.org/wiki/Saturn

Figure 6. Cassini Division.

Cassini calculated the distance between the Earth and the Sun to be about 87 million miles.

Cassini's most valuable contribution was probably the measurement of the distance to Mars. By comparing his own observations of the position of Mars with those made by the French astronomer, Jean Richer (1630–1696), he could arrive at the distance to Mars. The relative distances of the Sun and the planets were known accurately since the days of Kepler. Hence, knowing any one distance, every other distance could be determined. In particular, Cassini calculated the distance between the Earth and the Sun to be about 87 million miles. Only about 7 per cent lower than the actual distance, this was the first measurement which gave a value that was even nearly right. The previous estimates were in the range of five to 15 million miles.

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Suggested Reading

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