Astronomy for Curious Kids

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The Story of Astronomy

THINK
DIGITAL ACADEMY

Chapter 2

The Story of Astronomy

People have been looking at the sky for thousands of years, and coming up with ways to explain and predict the movement of the stars and planets. As the tools we use to study the Universe have improved, so has our picture of how it really works.

In this story, we'll look at how astronomy has changed over the centuries and how astronomers, with new inventions, have changed our understanding of Earth's position in the cosmos.

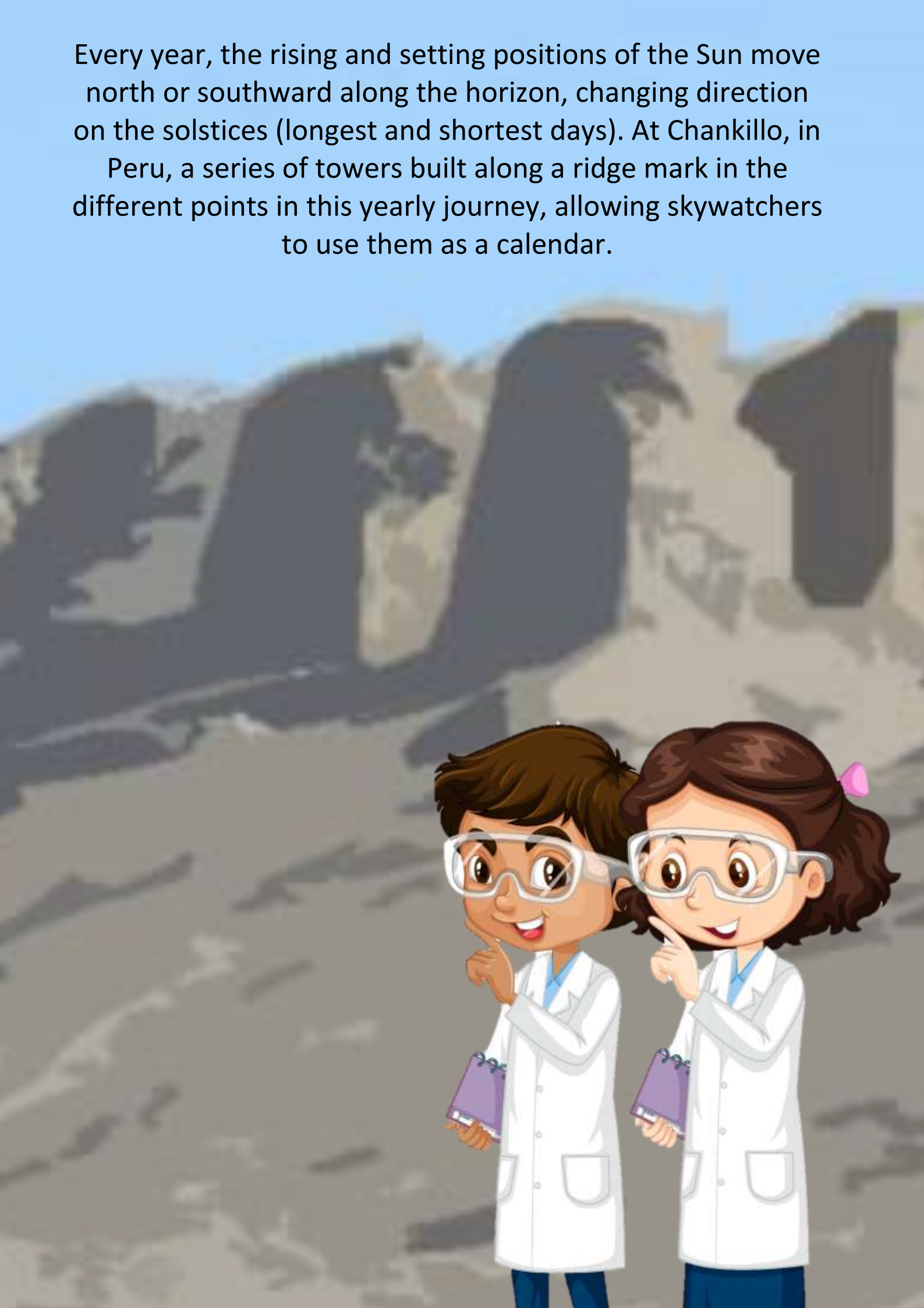
The First Stargazers

The first people who looked at the night sky didn’t keep a written record of their ideas about the Universe, but we can still figure out what they were studying from the traces they did leave behind.

Stone Stargazers

The prehistoric stone circle of Stonehenge in southern England was built around 5000 years ago. Key stones point in the direction of sunrise at midsummer (the longest day), while a ring of pits could have been used to track the motion of the Moon and perhaps predict when the Sun and Moon were likely to line up and cause an eclipse.

Every year, the rising and setting positions of the Sun move north or southward along the horizon, changing direction on the solstices (longest and shortest days). At Chankillo, in Peru, a series of towers built along a ridge mark in the different points in this yearly journey, allowing skywatchers to use them as a calendar.



Moon Mapping

Most of the time, the Moon is the only object with details that can be seen from Earth with the unaided eye. The earliest known Moon maps were carved on rocks at a tomb in Knowth, Ireland, about 4800 years ago.

Around the world, different people have seen patterns on the Moon's surface and told stories about them. In Europe and America, the most common of these is the "Man in the Moon." The dark areas of the Moon's surface can resemble that of a human face. In China, people see either a princess or a "Moon Rabbit."

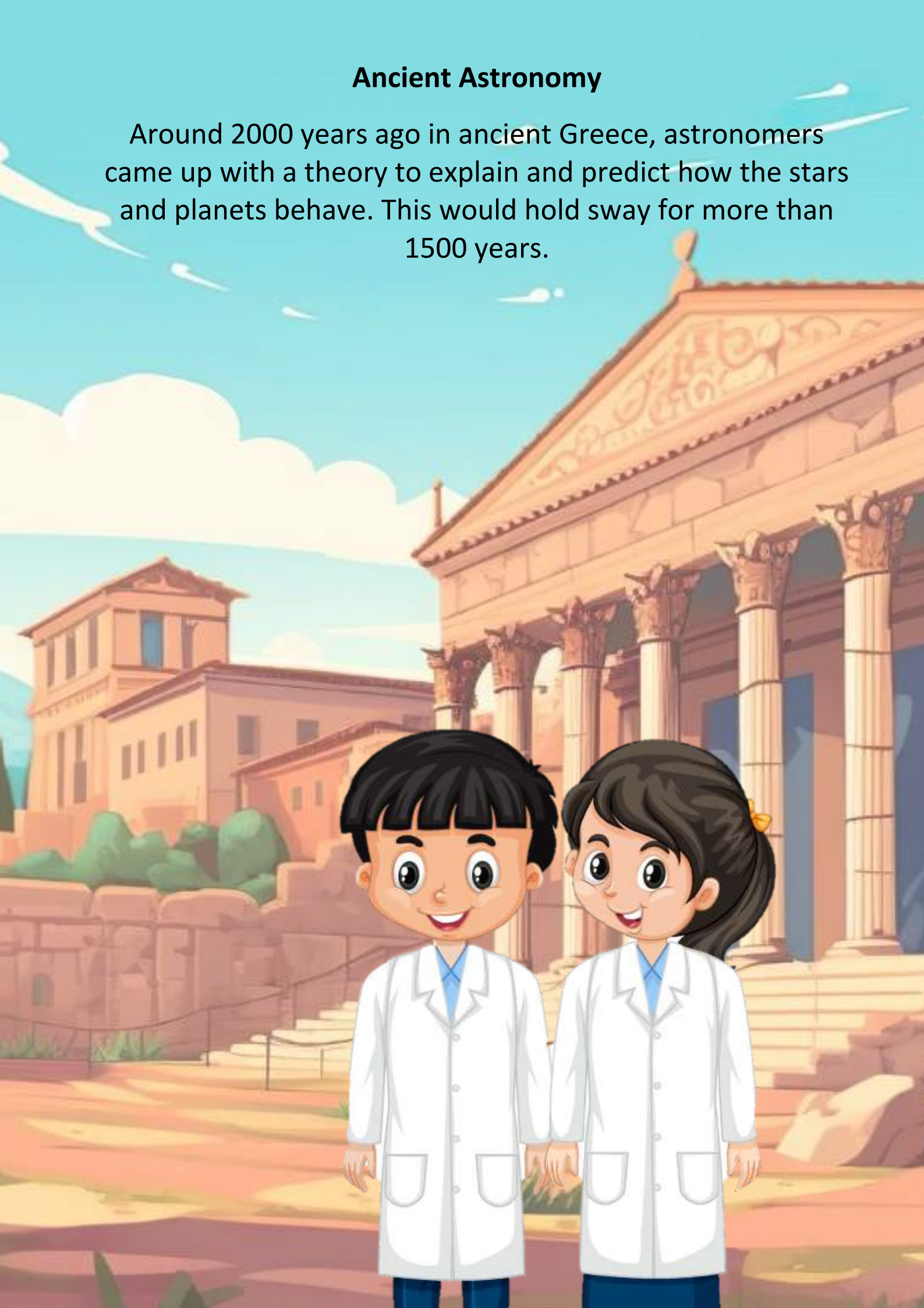
The Shifting Stars

As well as tracking the Sun, ancient people used the rising and setting of prominent stars through the year to keep tack of time. In ancient Egypt, the rising of the brightest star, Sirius, just before sunrise in late July, was used to predict the annual flood season of the Nile River.

The Egyptians depicted Sirius as the goddess Sopdet, with a brilliant star on her head.

Ancient Astronomy

Around 2000 years ago in ancient Greece, astronomers came up with a theory to explain and predict how the stars and planets behave. This would hold sway for more than 1500 years.



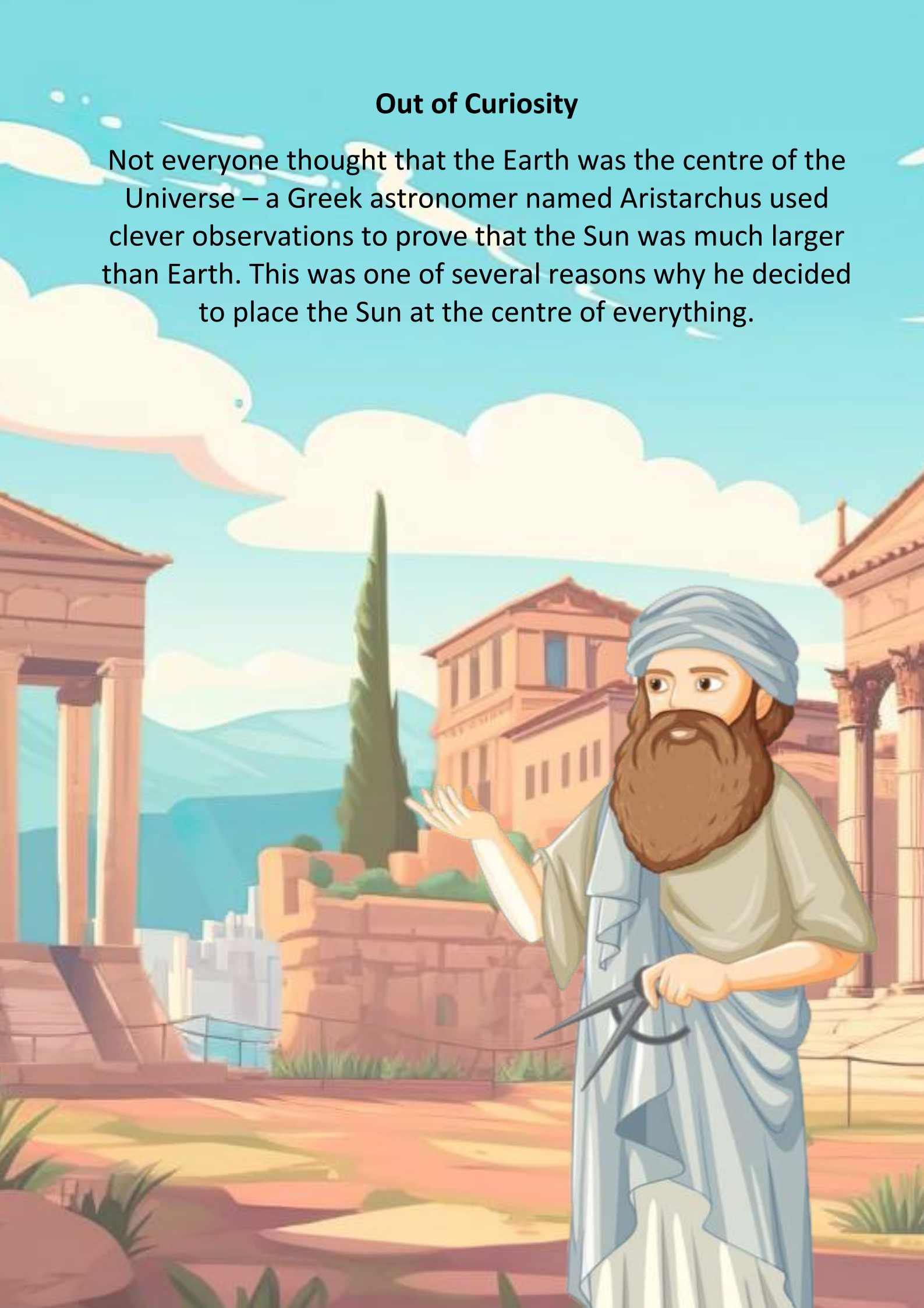
The Earth-Centred Universe

For ancient Greek astronomers, Earth was the biggest thing they could imagine and they had no way of knowing the size or distance of objects in the sky. It made sense to believe that Earth was the centre of the Universe, with the Moon, Sun, planets and stars circling around it at various distances.

The Greeks imagined that celestial objects sat on transparent crystal spheres that circled around Earth at different rates.

Out of Curiosity

Not everyone thought that the Earth was the centre of the Universe – a Greek astronomer named Aristarchus used clever observations to prove that the Sun was much larger than Earth. This was one of several reasons why he decided to place the Sun at the centre of everything.



Proving Earth is Round

Ancient Greek thinkers knew very well that Earth was a sphere, not a flat surface. Around 240 BCE, an astronomer named Eratosthenes even calculated the size of the Earth by showing how the Sun cast shadows of different lengths at different locations.

A clue to Earth's curved surface is that the masts and sails of ships sailing toward the horizon can be seen long after their hulls have disappeared from view.

Ptolemy's Epicycles

If the planets are circling around Earth, then why do they sometimes make backward loops in the sky? This was one of the biggest challenges to the Earth-centred theory of the Universe. However, in the second century CE, Egyptian astronomer Ptolemy came up with a clever solution called epicycles.

An epicycle is a smaller circle centred on a larger one. Ptolemy suggested that the planets moved around epicycles, which circled around Earth on a larger orbit. Because of this, movement around the epicycle could sometimes slow down or even reverse a planet's general drift around the sky.

Ptolemy’s idea of an Earth-centred Universe remained the dominant theory of more than a thousand years, but many new ways of understanding and interpreting the stars were developing around the world. These led people to challenge the old theories.

Islam and Astronomy

Followers of the new religion of Islam, founded in the seventh century had many reasons to be interested in the night sky. They began each month with the first sighting of a crescent moon after sunset. They also used the stars to decide the right times for prayers and to discover the precise direction of the holy city of Mecca for praying and building mosques.

Astrolabes and Accuracy

Astronomers in the Islamic world developed new tools for accurately measuring the position of objects in the sky, such as the astrolabe. Precise measurements showed that objects didn't always follow Ptolemy's theory, so clever thinkers such as Ibn al-Haytham (who lived in Iraq around the year 1000 CE), tweaked his ideas to make them fit.

An astrolabe is a metal circle with a loop at the top, so it can hang straight down. Marks around the edge divide the circle into 360 degrees and a sighting bar pivots in the middle. By tilting the bar so that it points at a star or planet, the user can measure its angle from the horizon. The astrolabe has many other uses.

Copernicus and Kepler

An Earth-centred of the Universe could never quite match the real movements of the planets. In the early 1500s, a Polih astronomer named Nicolaus Copernicus revived the idea of a Sun-centred Universe, but it took time to perfect his model.

Copernicus said that Earth was the third planet from the Sun, with the Moon in orbit around it. Mercury and Venus orbited closer in, which was why they always appeared near the Sun in Earth's skies. Mars, Jupiter and Saturn lay further out and made loops in the sky when Earth passed between them and the Sun.

Copernicus placed all of the planets on circular orbits, moving at steady rates around the Sun. unfortunately, he soon found that his model was no better than the Earth-centred one at predicting the actual movements of planets, so he had to add a system of epicycles similar to Ptolemy's.

Kepler’s Laws

In the early 1600s, German mathematician, Johannes Kepler, took a fresh look at the motion of planets, based on precise records of the movement of Mars. He realised that the orbits of the planets were elongated ellipses rather than perfect circles, and he outlined three laws of planetary motion.

First Law

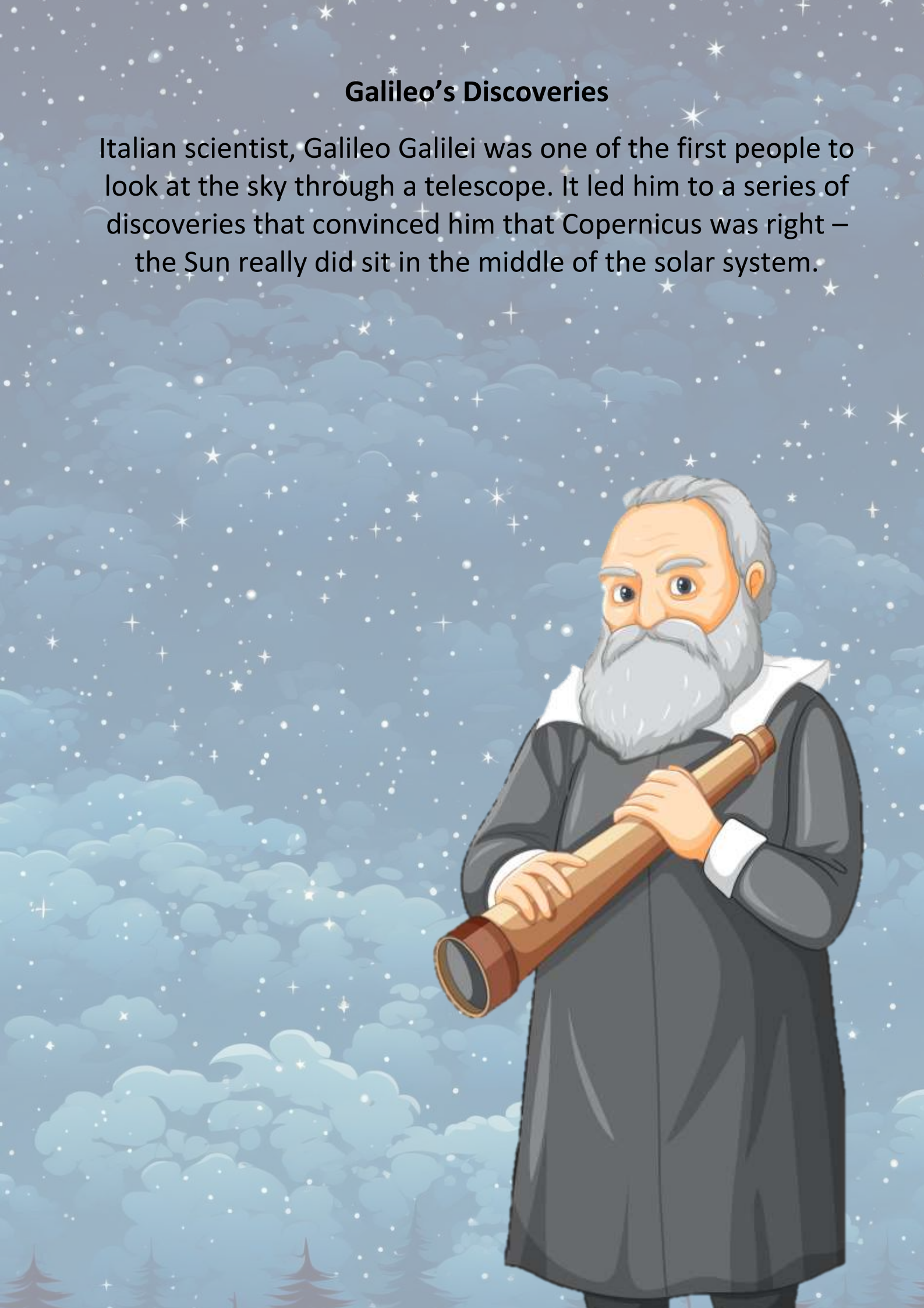
Planets orbit following ellipses (circles stretched in one direction), with the Sun at one of two focus points on either side of the centre. A circle is just a special type of ellipse with both focus points on the exact centre.

Second Law

A planet moves more slowly when it is further from the Sun and faster when it is closer to the Sun. a line between the Sun and a planet “sweeps out” equal areas in equal times.

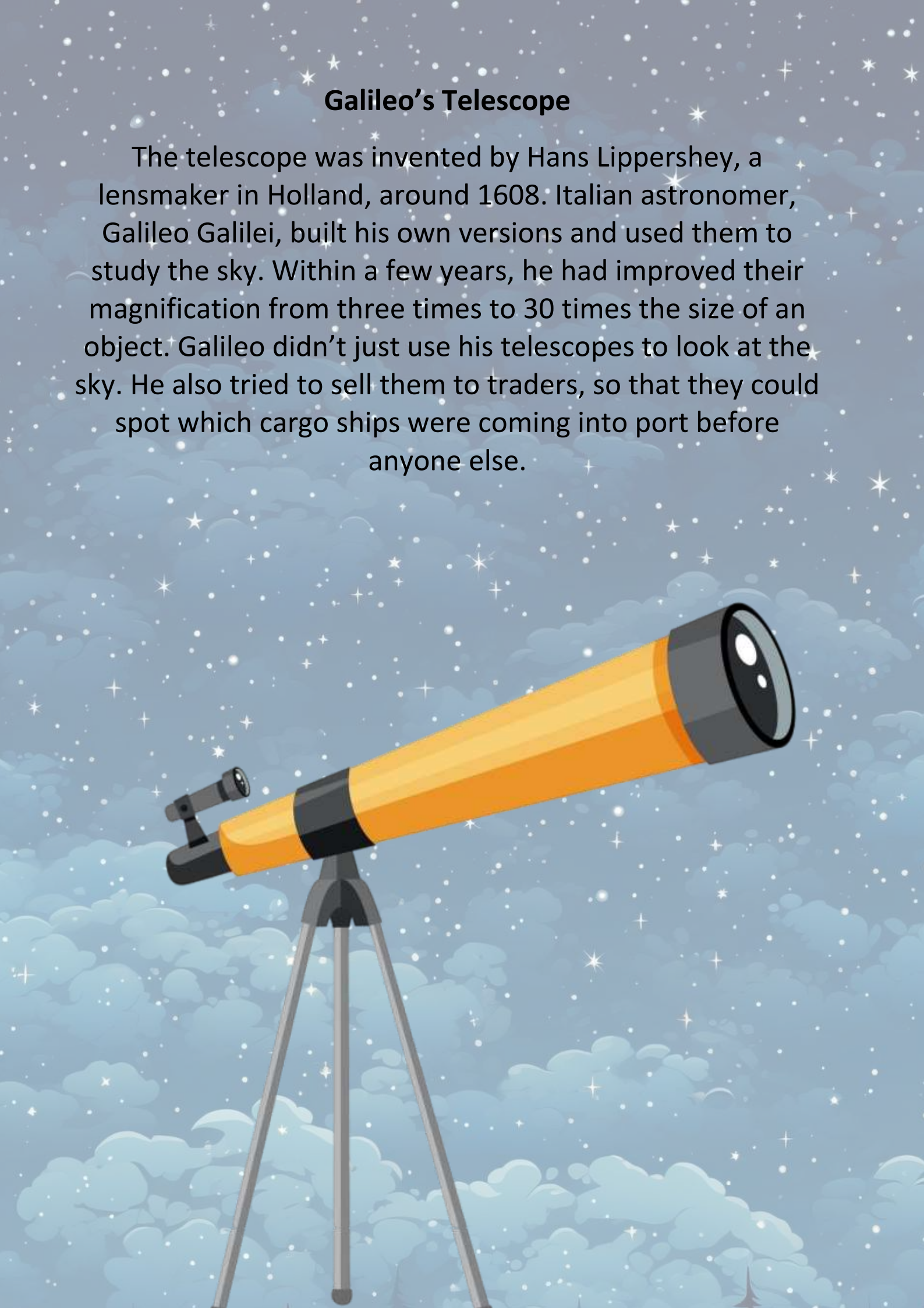
Galileo’s Discoveries

Italian scientist, Galileo Galilei was one of the first people to look at the sky through a telescope. It led him to a series of discoveries that convinced him that Copernicus was right – the Sun really did sit in the middle of the solar system.



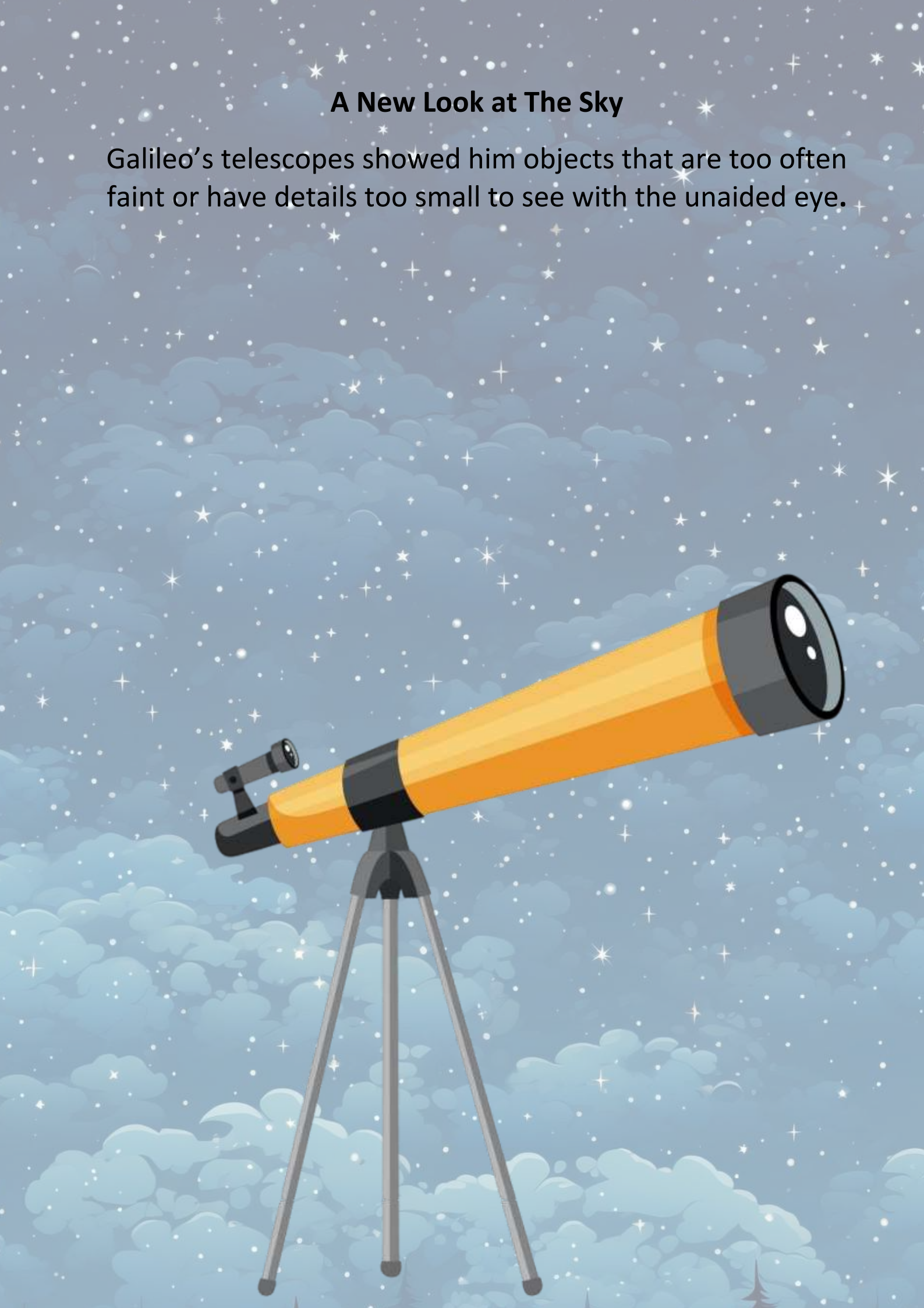
Galileo’s Telescope

The telescope was invented by Hans Lippershey, a lensmaker in Holland, around 1608. Italian astronomer, Galileo Galilei, built his own versions and used them to study the sky. Within a few years, he had improved their magnification from three times to 30 times the size of an object. Galileo didn’t just use his telescopes to look at the sky. He also tried to sell them to traders, so that they could spot which cargo ships were coming into port before anyone else.



A New Look at The Sky

Galileo’s telescopes showed him objects that are too often faint or have details too small to see with the unaided eye.



Phases of Venus

When Galileo looked at Venus, the brightest planet in the sky, he found that it went through a series of Moon-like Phases. These showed that it was orbiting the Sun and changing its appearance depending on how much of its sunlit face was visible from Earth.

Moons of Jupiter

When he looked at Jupiter, he saw that it was a disk, with four small “stars” in a line around it. As he watched these stars move back and forth, he realised they were moons circling Jupiter. This showed that not everything in the Universe orbited around Earth or the Sun.

Mountains on the Moon

Looking at the surface of the Moon, Galileo saw mountains, craters and dark plains he called “seas”. Earlier astronomers had believed that the Moon and Sun were perfect spheres, but these discoveries showed that it was a rugged world like Earth.

Galileo on Trial

Galileo revealed these discoveries and others in a book called The Starry Messenger. He became a strong supporter of Copernicus' ideas, but because the Catholic Church supported Ptolemy's Earth-centred Universe, this got him into trouble. He spent the last years of his life under house arrest, but he is now regarded as a hero of science.

Great Telescopes

year	Telescope	
1609	Galileo's refractor	First telescope used to observe the night sky
1668	Newton's reflector	First mirror-based telescope design
1673	Hevelius' aerial telescope	Had a 20 cm (8 in) lens, requiring a 46-m (150 ft) – long frame
1845	Leviathan of Parsonstown	First giant mirror telescope, with a 1.83 m (72 in) diameter
1897	Yerkes Refractor	Largest lens-based telescope, with a 1.02m (40 in), diameter
1948	Hale Telescope	5 m (16 ft) mirror telescope
1990	Hubble Space Telescope	First large visible light telescope in orbit
2009	Gran Telescopio Canarias	World's largest single telescope, with a `0.4 m (410 in) mirror
2027	Extremely Large Telescope	Giant telescope with a 39.3 m (129 ft) mirror

Charting the Sky

Before the 1800s, astronomers were mostly interested in measuring the positions and movements of the stars and planets. With this in mind, they built elaborate observations and compiled their measurements in beautiful star atlases.

The Age of Observations

Observations are special buildings designed to house and protect telescopes and other astronomical instruments. Having these instruments, fixed in place and correctly lined up with the sky, was key to accurately measuring the position of stars.

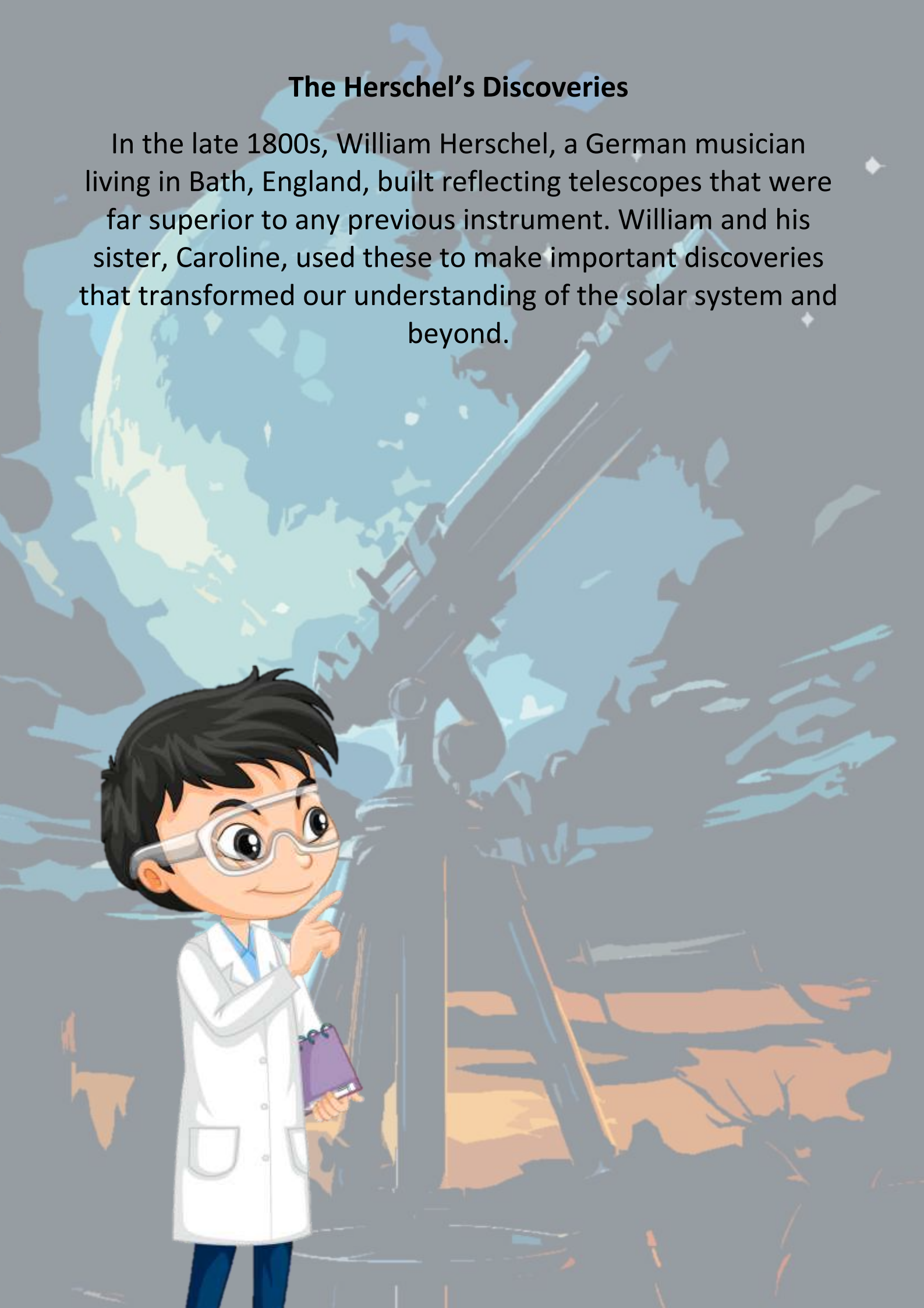
Polish astronomer, Johannes Hevelius, built and observatory platform spanning three rooftops in the city of Gdarisk. His instruments included devices for measuring the precise positions of the stars and planets, as well as a telescope with a tube some 46 m (150 ft), long to get the best magnification.

Hevelius' Atlas

The invention of telescopes meant that astronomers could see many more stars and other objects. Making accurate mas of their locations became increasingly important and many astronomers in the 1700s set out to make elaborate star atlases. One of the most important was made by Hevelius and published in 1687.

The Herschel's Discoveries

In the late 1800s, William Herschel, a German musician living in Bath, England, built reflecting telescopes that were far superior to any previous instrument. William and his sister, Caroline, used these to make important discoveries that transformed our understanding of the solar system and beyond.



New Planets

In 1781, William Herschel was charting the stars when he discovered what at first, he thought was a new comet. It turned out to be something far more important – a new planet, which was later named “Uranus”. By the 1840s, astronomers realised that Uranus’ movement was being influenced by another unseen world, which led to the discovery of the outermost major planet, Neptune.

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Double Stars

Herschel discovered that many stars that looked like single objects at first, were actually close pairs when seen through a telescope. He showed that these couldn't all be chance alignments – instead, the double stars must be genuine pairs in orbit around each other.

Out of Curiosity

In a time when clocks were not reliable, the sky was the only accurate way of figuring out both the time and a stargazer's position on Earth. People hoped that the more precise maps and a better understanding of how the planets moved could be the key to safe and accurate navigation of ships.

The Birth of Astrophysics

Beginning in the 1800s, astronomers learned how to measure the properties of stars – their temperatures, sizes, masses and even the chemicals they contained. This allowed them to unlock the secrets of how the stars shine.

Apart from the Sun, every star in the sky is so far away that it appears as just a point of light through even the most powerful telescopes. By measuring the distance to stars for the first time, astronomers were able to discover their true luminosities – the amount of energy that they pump out as light. When they realised that a star's colour was related to its surface temperature, they had key to calculating the stars. They discovered that stars vary hugely in luminosity, temperature and size.

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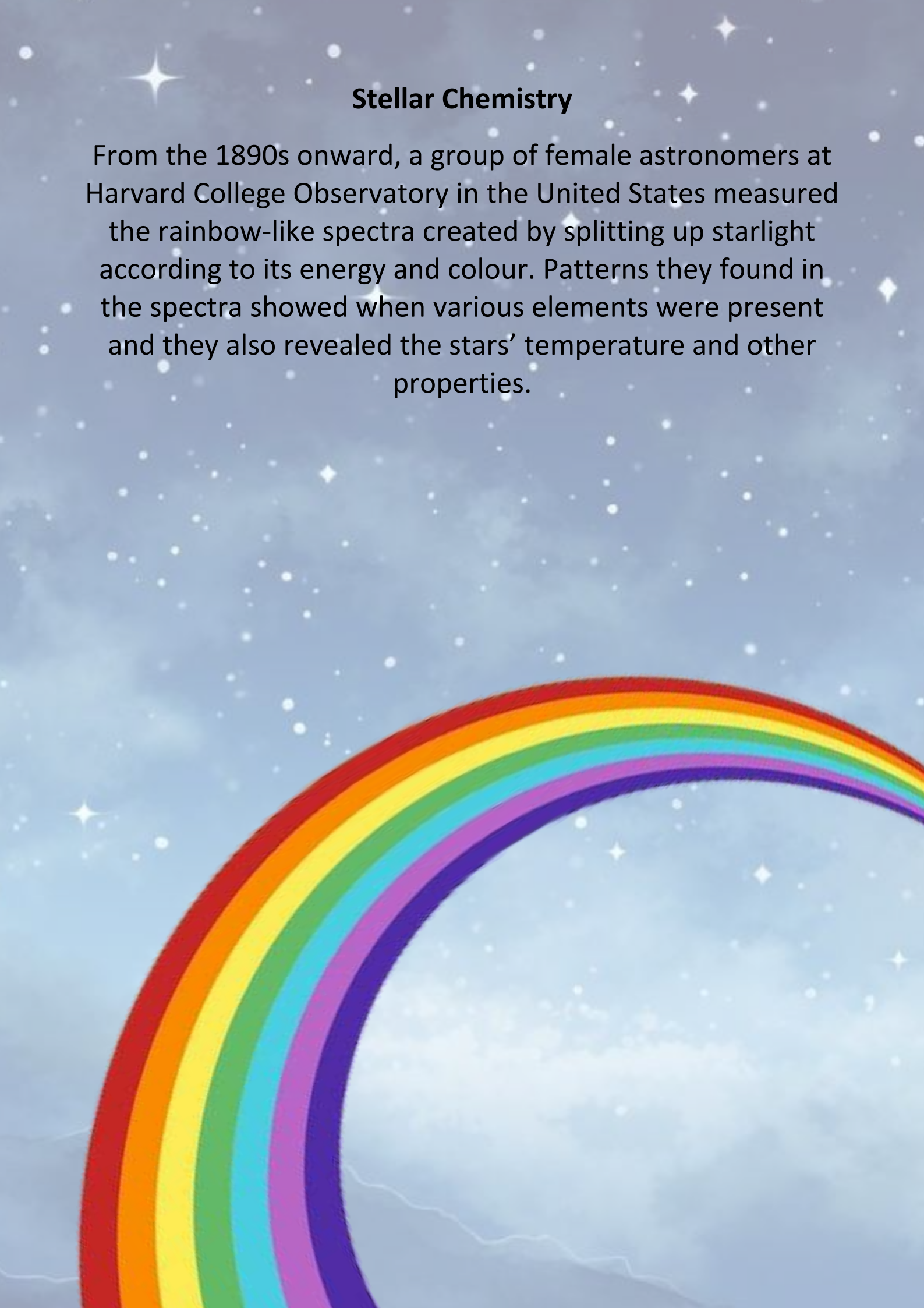
Supergiants are rare and incredibly luminous stars. They may have the mass of many Suns and pump out a million times its energy, sometimes shining with intense blue light.

Stellar Chemistry

From the 1890s onward, a group of female astronomers at Harvard College Observatory in the United States measured the rainbow-like spectra created by splitting up starlight according to its energy and colour. Patterns they found in the spectra showed when various elements were present and they also revealed the stars' temperature and other properties.



Weighing the Stars

After astronomers discovered that some stars form pairs orbiting each other, they had a way of comparing their masses – the lighter star has a bigger orbit, while the heavier one moves less and is closer to the system's balance point or "centre of mass." Comparing the masses of stars with their colour, size and luminosity revealed important patterns.

The Power Source of Stars

In 1920, British astronomer Arthur Eddington suggested that the stars might be powered by nuclear fusion, forcing together lightweight elements to form heavier ones and release energy. This theory explained the huge difference in the luminosity of stars. A small difference in mass can make a big difference to the rate at which fusion reactions take place and the total amount of energy that the star can pump out.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