4

The Old World

4.1 Greek Myths, Art, and Astronomy

Ancient Greece was a land of innovative art, philosophy, mathematics, and mythology. As in many ancient populations, the Sun was honored as a god. Helios, which in Greek means "Sun," was their Sun god. He drove a chariot across the sky from east to west and sailed on the sea every night. It was a common idea in early human cultures to picture a Sun god crossing the sky in this way and disappearing into the underworld, the land of the dead, or in this case, sailing across the sea. After all, the Sun had to go somewhere at night, so different legends invented a mysterious and dark place for the Sun to rest, before reappearing in the east and continuing his daily routine toward the west. Helios was regarded as the most important god, worshipped especially on the island of Rhodes. Apollo, the deity of purity, was his successor as Sun god, worshipped by the Romans.

Ancient Greek religion was closely connected with astronomy and astrology. Gods and goddesses had superior powers, but at the same time they had human feelings and even a human appearance. The Greeks put their gods in the stars and in the planets, although we use the Roman names for the latter today, i.e., Mercury, Venus, Mars, Jupiter, Saturn, and Neptune. The constellations were named after semi-divine mythological entities, including the gods' favored heroes and the gods' favored animals, such as Andromeda, Aquila, Auriga, Cassiopeia, Cygnus, Orion, Ursa Major, although these are once again the Roman names. And needless to say, the twelve signs of the zodiac were also linked to Greek mythology.

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Western civilization probably could not have existed without Ancient Greek culture, art, philosophy, astronomy, and mathematics, and even their myths and legends influenced subsequent civilizations. In fact, Greece is the reason we have our Western civilization, and it's not an exaggeration! During the Classical period, which lasted about 200 years from the fifth to the fourth centuries BC, art and science flourished thanks to the ingenious minds of men who lived at that time; men such as Empedocles, a philosopher and astronomer, who, in the fifth century BC, was able to demonstrate that the Earth was round. He understood this during a lunar eclipse, when the curved edge of the Earth's shadow passed across the Moon.

Empedocles, who lived from ca. 490 BC to ca. 430 BC, was born to a well educated and wealthy family in Sicily, at that time part of Greece. He studied with the Pythagoreans, but very likely never met Pythagoras himself, as the latter probably died several years before Empedocles was born. He firmly believed that numbers were the most important thing in the Universe. For him, they were the most perfect entities and perhaps the only way to understand the world around us. He believed that there were only four basic elements: air, fire, water, and earth. He also claimed that the speed of light was finite and that mass was conserved in chemical reactions. A proper theory of mass conservation was only formulated much later, in the 1770s, by the well-known French chemist Antoine Lavoisier.[1] The amazing and ingenious mind of Empedocles! He foresaw and formulated this theory many centuries before Lavoisier.

In astronomy, Empedocles, like all scientists at that time, assumed the geocentric model. He conceived of the Sun as a vast ball of fire, and taught that its light must have taken some time to reach Earth, that it could not have reached us instantly, thus inferring that the speed of light was finite. He was perfectly correct. In fact, light from the Sun takes about eight minutes to reach Earth.

Many philosopher-physicists who lived in Ancient Greece made essential contributions to science. Parmenides was another mathematician and astronomer who recognized the roundness of the Earth. He also understood the different phases of the Moon, realizing that the changes were caused by the relative positions of the Sun and the Earth.

Then there was Pythagoras, philosopher, mathematician, and astronomer, who was born in Samos in about 570 BC and died in a region of southern

[1] Antoine Laurent Lavoisier is considered one of the founders of modern chemistry, but he was also an administrator, and an important financier during the French Revolution. Those were bad times to be an aristocrat, and especially a much hated tax collector. It did not help to be the most famous scientist of the day, as he was guillotined anyway during the Terror of the French Revolution, in 1794.

Italy that was at the time colonized by the Greeks. From their astronomical observations, he and his followers, the Pythagoreans, produced a model of the Solar System that was not geocentric. They postulated that, at the center of the Universe, there was a large primordial fire, called Hestia, encircled by an anti-Earth, the Moon, the Sun, Mercury, Venus, Mars, Jupiter, and Saturn. This was a truly innovative concept at a time when the geocentric model was predominant.

But it was the great philosopher Plato who put forward the first model of a heliocentric universe, although later in his life, he went back to the geocentric model. He too, like Parmenides, understood that the Moon received light from the Sun.

Aristotle was a philosopher, mathematician, and astronomer, and generally one of the most brilliant minds in antiquity. He believed that the Earth was composed of the four elements earth, water, air, and fire, together with another, mysterious fifth element or essence, which he called "ether." This was an invisible, massless, eternal element, pervading an immutable cosmos. Now it so happens that Aristotle's idea of "quintessence," has been borrowed by some contemporary cosmologists. It pertains to the problem of the mysterious dark matter and dark energy receiving much attention these days. A few years ago, I had the chance to discuss this with a well-known cosmologist, Christof Wetterich, professor at the University of Heidelberg in Germany. He published a paper entitled "Quintessence." I was inspired by his scientific paper and by the simple way he explained this difficult physical concept. After our discussion, I painted my version of "quintessence" on canvas.

He explained to me that his quintessence bore no resemblance to Aristotle's ether as the fifth element. There has already been a modern version of the ether, before Einstein's theory of relativity made it redundant. It was supposed to be the medium in which electromagnetic waves propagate. The modern version of ether was considered to fill all space between matter. Dark energy, on the other hand, as Professor Wetterich points out, reflects a propriety of the vacuum which is needed to explain the accelerating expansion of the Universe. So, the difference between Aristotle's quintessence and Professor Wetterich's is actually quite great. However, in my unscientific mind, I see in the idea of Aristotle's mysterious fifth element the seed for the modern ether, and dare to compare it with "dark energy."

Following the Classical period of Ancient Greece, there came the Hellenistic period, which lasted three centuries, from the death of Alexander the Great in 323 BC to the conquest of Greece by Augustus in 31 BC. This era was certainly a golden age for science. Many important contributions were made by philosophers—at that time, there was no clear distinction between physics and philosophy, and philosophers were in effect scientists.

Aristarchus of Samos, who studied the motions of the celestial bodies, proposed a heliocentric model. He also understood that the Earth was spinning on an axis that was tilted with respect to the plane of its orbit around the Sun, since this explained the changing seasons.

The mathematician and astronomer Hipparchus was born in Nicaea in the Kingdom of Bithynia, modern day Iznik in Turkey, in about 190 BC, and died in about 120 BC in Rhodes, by then a Roman Republic, now in modern day Greece. He made fundamental contributions to astronomy. Using old observations from star catalogs, he created a new one containing 850 stars, assigning each its celestial longitude and latitude. He classified the brightness of the stars, now known as stellar magnitudes, on a scale from one to six.

Such catalogs have been compiled over the centuries by many different civilizations, including the Babylonians, Greeks, Chinese, Persians, and Arabs. The earliest known catalogs were compiled by the Babylonians in the second millennium BC and inscribed on clay tablets. One such listed thirty-six stars. In the Hellenistic world, many astronomers and mathematicians compiled star catalogs, but it was Hipparchus who made the most complete catalog. Indeed, he was probably the earliest to map the entire sky, or at least the part that was visible to him. In Roman Egypt, Ptolemy published a star catalog listing 1022 stars, almost entirely based on the one compiled by Hipparchus, as part of his treatise *The Almagest*. It remained the standard star catalog in the Western and Arab worlds for over a thousand years until Tycho Brahe's catalog appeared in 1598.

According to the writings of the Roman naturalist Pliny the Elder, in his star catalog, Hipparchus indicated the names and measured positions of each star. Through his astronomical observations of the orbits of the Sun and Moon, he was able to calculate their sizes and their distances from the Earth, and also predict solar eclipses. He was able to calculate the equinoxes and solstices because he understood about our planet's axial tilt. The Earth is tilted on its axis as it travels around the Sun, so at any given point on the surface, the Earth receives different amounts of sunlight at different times of the year. If the Earth were not slightly tilted on its axis, the Sun would always appear directly overhead at the equator. In this case, there would be no need to look out for solstices and equinoxes to mark the changing of the seasons. The equinoxes fall on about 21 March and 23 September. These are the days when the Sun is exactly overhead at the equator, making the day and night of equal length. The solstices fall on about 21 June, the summer solstice, which marks the longest day of the year, and on about 21 December, the winter solstice, which marks the shortest day of the year.

Philosophy, mathematics, astronomy, and art flourished in Ancient Greece more than in any other culture in Antiquity. Art, in particular, was a discipline based on mathematical principles, and the Greeks took the view that there was a strong similarity between art and science. Mathematics is often considered analytical, while art is considered creative, but they can also be viewed the other way around, with art analytical and mathematics creative. In the end, both are able to inspire the imagination. Good examples of these two disciplines can be seen in Greece during both the Classical and the Hellenistic periods. Astronomers and mathematicians like Plutarch and Hippocrates were effectively using some of the same skills for their scientific work as their contemporaries, people like Phidias and Polykleitos, for their artwork.

In Classical Greek art, the sense of beauty was reached solely through mathematical concepts of symmetry, geometry, and proportions, with the same approach that mathematicians and astronomers used in their work.

But during the Hellenistic period, the arts were considered inferior to those of the Classical period. There was in effect a change by artists in their expression of visual art. From my point of view, and I am not alone, art got even better in the Hellenistic period, as compared with the Classical period. Sculptures became more realistic and more expressive. The anatomical perfection, the mathematical symmetry, and the proportions were kept as they were in Classical art, but artists took a different approach. They were more interested in representing the individual character of the subject. They represented common people, whether young, old, beautiful or otherwise. This was a new understanding of the arts compared to the somewhat over-idealized figures of the Classical era. There was a difference especially in sculpture: artists portrayed not only beautiful people, but also ordinary subjects with wrinkles, flabby faces, or big noses, if that was actually the face of the person they were sculpting. Art follows the changing culture of the time, and the culture was indeed changing.

4.2 The Roman Empire

The history of the Roman Empire is a vast subject. Everything began in the sixth century BC with the Republic, but by the third century BC, there was a significant expansion beyond the original territories. The Roman Empire was founded in 27 BC, after Octavian Augustus became the sole ruler in 31 BC, and it lasted until 286 AD, which marked the beginning of the Middle Ages. Famous are the words of the Emperor Augustus about his reign, as quoted by

the Roman historian Suetonius: "I found Rome a city of bricks and left it a city of marble."

Under the Emperor Augustus, Rome became the biggest empire in Antiquity, a truly vast empire. It expanded from the region of Etruria in the Italian peninsula to the Mediterranean basin during the Punic wars, and then to continental Europe under Pompey and Julius Caesar, with the conquest of Britannia, Gaul, and Hispania. Then followed the regions of Mauretania, Numidia, and Egypt in North Africa, and Syria, Judea, and Partia in the east and the Middle East, not to mention Asia Minor, Greece, Macedon, and Dacia, and then the islands of Cyprus, Corsica, Sardinia, and Sicily. As the imperial capital, Rome was embellished with magnificent palaces, temples, public baths, theaters, and stadiums (Fig. 4.1).

Following the conquest of Greece, the Romans adopted the Greek culture, including their religion, arts, and science. The Greek language was highly esteemed and was spoken in particular by the elite and intellectuals. Regarding their religion, the Roman Empire was polytheistic. Many gods and goddesses were worshipped, and there were also minor monotheistic religions such as Judaism and the beginnings of Christianity. But the single most influential culture in Rome was the Greek's.

Greeks and Romans worshipped the same gods with different names, for example, Jupiter for Zeus, Juno for Hera, and Minerva for Athena, along with many others. One early Sun god, Sol Indiges, was not represented in Greek religion, but appears in the later Roman Empire as Sol Invictus, which means the "unconquered Sun." So this was a Sun god never worshipped by the Greeks, but very important to the Romans.

When Rome was founded, they introduced the worship of Sol Indiges, a Sun god that was not represented in Greek religion, and this veneration lasted for the first three centuries. According to the Roman historian Tacitus, an old temple had been built in the Circus Maximus during the early agrarian Rome. At the time, Sol Indiges was still of some importance as a Sun god. But following the conquest of Greece, the Romans began to identify the Greek deities with their own, although using different names. For example, Jupiter became Zeus, Juno became Hera, and Minerva became Athena, along with many other such identifications. Apollo became the counterpart of the Greek Sun god Helios, idealized as a beautiful and radiant young man. For the Romans, Apollo was also a god of the arts and science, sometimes portrayed with a musical instrument, the lyre, and also pictured on a golden chariot towed across the sky by four horses (the quadriga). Apollo was identified as a Sun god with human features. It was common in Greek and Roman religion to depict deities with human looks. A beautiful young man, who loved poetry

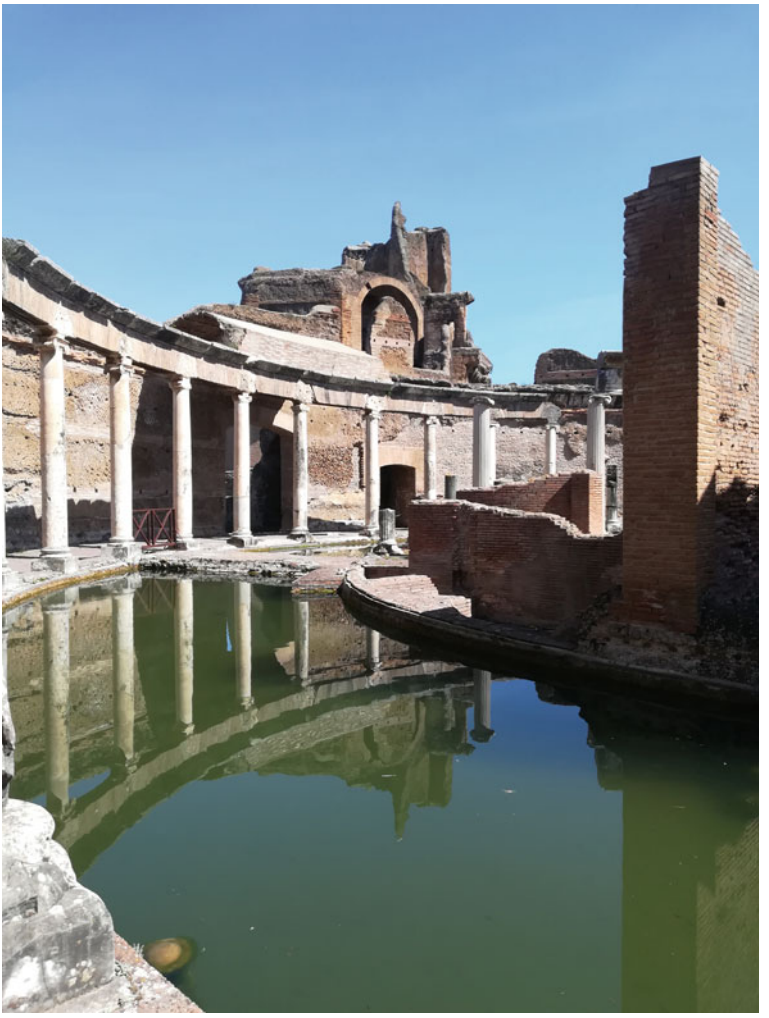

Fig. 4.1 Ancient Rome. The Emperor Hadrian's villa, Tivoli, Italy. Photo by the author

and music, and loved many goddesses, and many human women, with whom he had twenty-nine children. And, as was typical in Antiquity, he also loved many beautiful young men.

During Imperial Rome, Apollo was less important as a Sun god. It was not until the Late Roman Empire that the Sun god became the most important and powerful god in the pantheon of Roman religion, going by the name of Sol Invictus, the "unconquered Sun," honored and worshipped by Emperor Aurelian. Sol became a major divinity and a great temple was built in the Campus Agrippae in Rome. Sol Invictus became a symbol of the victory

in the campaign of Palmyra,[2] in modern Syria, which took place on 25 December 274 AD (Fig. 4.2).

Ancient Rome celebrated the birth of Sol Invictus on 25 December. It was the Emperor Aurelian who established the Sun cult as the official religion of the empire, later continued by Emperor Constantine I. However, eventually, with the growth of the Christian faith, Constantine abolished the pagan cult of Sol Invictus in favor of the new religion. It was Constantine who wanted to portray the symbol of Sol Invictus on coins, and later declared "Dies Solis"—the day of the Sun, or Sunday—as a day of rest for the Romans. Consequently, according to some historians, it was Constantine who declared 25 December to be the day of Christ's birth. So, this was clearly a major historical and cultural change, replacing the celebration of Sol Invictus by what we now call Christmas!

In a way, we can say that Sun god worship is still happening today, if we replace the Sun god with the Christian god, Jesus Christ. It seems like the sunray symbol for Sol Invictus in the late Roman Empire became a symbol of

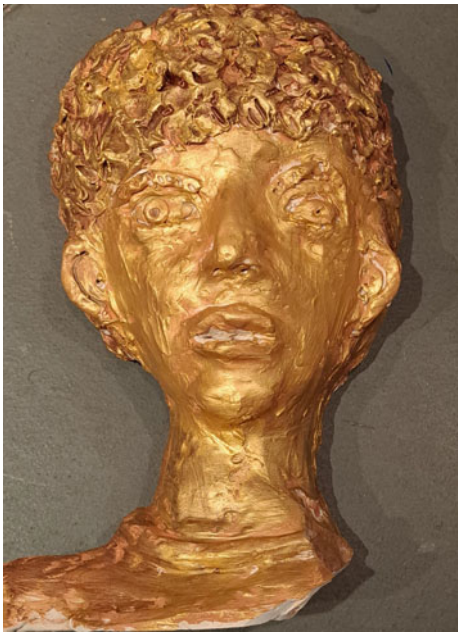

Fig. 4.2 The Emperor Aurelius. Terracotta sculpture painted gold

[2] Unfortunately, the historical city of Palmyra was destroyed in 2013 by the senseless fanatical terrorists of ISIS. The reason, according to them, was that it did not conform to their strict interpretation of Islam, like anything predating the Islamic era.

Christianity in medieval Europe, representing Jesus Christ and the Christian saints with golden halos.

4.2.1 Art and Science in Ancient Rome

The golden age of art and science in Greek culture was basically continued into Imperial Rome. In the arts, the Romans applied the geometrical formula used by Greek artists, known as the golden mean or golden section, in their attempts to reach perfection, especially in sculpture. However, there was a difference between the two cultures: the Romans were more concerned with individuality than the Greeks of the Hellenistic period. Roman artists sought to create realistic portraits that would capture the character of the particular subject they were representing.

In science, there was also a continuation from Greek mathematics and astronomy. Roman astronomers studied the motions of the celestial bodies, and like the Greeks before them, they attributed the names of gods and other mythical figures to the planets and constellations. The most famous astronomer of all was without doubt Claudius Ptolemy, who lived from about 100 to 170 AD in Egypt, which was at that time part of the Roman Empire. He wrote scientific treatises of great importance for Western European science, especially during the Middle Ages. The Almagest and the Tetrabiblos were Ptolemy's best known works. He was the last great astronomer of Antiquity, and the most influential astronomer in Europe, the Middle East, and North Africa.

Ptolemy favored a geocentric model of the Universe, as did most of his predecessors. Indeed, Ptolemy's geocentric model was accepted until the simpler heliocentric picture resurfaced in the seventeenth century. Ptolemy's model thus took the Earth as stationary at the center of everything, with the Sun, Moon, and the other planets moving around the Earth. The stars were all fixed to an outermost sphere and carried around the Earth in circular orbits. An inexplicable and mysterious power had to keep the celestial bodies in motion. This apparently simplistic and relatively successful model was in reality far from simple. To make it work, he had to hypothesize the motions of the planets as occurring not only in circles around the Earth, but also in smaller circles superposed on those bigger ones! At any rate, this geocentric model was accepted for centuries, especially while Christianity held sway in the Middle Ages. Man at the center of creation! Just as affirmed by the sacred Judeo-Christian scriptures.