John Freely was born in New York in 1926 and joined the US Navy at the age of 17, serving during the last two years of World War II. He has a PhD in physics from New York University and did postdoctoral studies in the history of science at Oxford. He is Professor of Physics at Bosphorus University in Istanbul, where he has taught physics and the history of science since 1960. He has also taught in New York, Boston, London and Athens. He has written more than 40 books, including works on the history of science and travel. His most recent books on the history of science are *Flame of Miletus: The Birth of Science in Ancient Greece* (2012) and *Light from the East: How the Science of Medieval Islam Helped to Shape the Western World* (2011). His recent books on history and travel include *The Grand Turk*, *Storm on Horseback*, *Children of Achilles*, *The Cyclades*, *The Ionian Islands* (all I.B.Tauris), *Crete*, *The Western Shores of Turkey*, *Strolling Through Athens*, *Strolling Through Venice* and the bestselling *Strolling Through Istanbul* (all Tauris Parke Paperbacks).

To my beloved Toots.

Figure 1 Nicolaus Copernicus, from the 1554 Paris edition of his biography by Pierre Gassendi, presumably based on the self-portrait mentioned by Stimmer.

Celestial Revolutionary

Copernicus, the Man and His Universe

JOHN FREELY

I.B. TAURIS
LONDON · NEW YORK

Published in 2014 by I.B.Tauris & Co Ltd
6 Salem Road, London W2 4BU
175 Fifth Avenue, New York NY 10010
www.ibtauris.com

Distributed in the United States and Canada
Exclusively by Palgrave Macmillan
175 Fifth Avenue, New York NY 10010

ISBN: 978 1 78076 350 7
eISBN: 978 0 85773 490 7

A full CIP record for this book is available from the British Library
A full CIP record is available from the Library of Congress

Library of Congress Catalog Card Number: available

Typeset by Newgen Publishers, Chennai
Printed and bound in Sweden by ScandBook AB

CONTENTS

ILLUSTRATIONS

INTRODUCTION

This is a biography of the Polish astronomer Nicolaus Copernicus (1473–1543), who at the dawn of the Renaissance proposed the revolutionary theory that the earth and the other planets were in orbit around the sun, breaking with the geocentric cosmology that had been the world view since antiquity.

The heliocentric theory, as it was called, was published in 1543, just before Copernicus' death. His book is entitled *De revolutionibus orbium coelestium libri VI* (Six Books Concerning the Revolutions of the Heavenly Spheres), a truly revolutionary work whose reverberations were felt far beyond the realm of astronomy. During the first century after its publication, the Copernican theory was accepted by only a few astronomers, most notably Kepler and Galileo, but their new sun-centred astronomy sparked the seventeenth-century Scientific Revolution that climaxed with the new world system of Isaac Newton, the beginning of modern science.

Despite its great importance *De revolutionibus* appeared in only two editions, the first in 1543 and the second in 1566, and it was not translated into English until 1952, the year after I began earning my living as a physicist. Though his *De revolutionibus* has been called 'the book that nobody read,' it changed our view of the universe forever, breaking the bounds of the finite geocentric cosmos of antiquity and opening the way to the infinite and expanding universe of the new millennium.

CHAPTER 1

'THIS REMOTE CORNER OF THE EARTH'

Sigismondo de' Conti, the papal secretary, noted in his chronicle during the spring of 1500 that 'All the world is in Rome.' A few days before Christmas 1499 Pope Alexander VI Borgia had declared that the following year would be a Jubilee, a period of special solemnity, in accordance with the decree published in 1471 by Pope Paul II which declared that each 25th year of the Christian era should be celebrated thusly. A special indulgence would be granted to all pilgrims who came to Rome and visited the four principal churches of the city, beginning with St Peter's, whose doors would be open night and day throughout the Jubilee. The celebrations went on throughout the year, and on Easter Sunday an estimated 200,000 pilgrims thronged St Peter's Square for the Pope's blessing. The pious monk Petrus Delphinus was led to exclaim 'God be praised, who has brought hither so many witnesses to the faith.'

Among the pilgrims was a young student named Nicolaus Copernicus, who had come from Poland to Italy in the autumn of 1496 to enrol in the faculty of law at the University of Bologna. The Italian Renaissance was in full bloom and Copernicus was in Rome at the height of its glory, before returning home the following year. He came back to Italy later that year to study medicine at the University of Padua for two years, before going to the University of Ferrara, where in 1503 he received a doctorate in law. He then returned to what he later called 'this remote

corner of the earth,' in present-day northern Poland, where he would remain for the rest of his days.

One of the earliest biographies of Copernicus, a somewhat unreliable work in Latin published in 1654 by the French philosopher and astronomer Pierre Gassendi, gives his name as Nicolai Copernici, one of many forms that appear in various sources, including the astronomer's own correspondence, Nicolaus Copernicus being the one now generally used.

Copernicus was born on 19 February 1473 in a house on Saint Anne's Street in Thorn (Torun), a town on the Vistula, 110 miles south of Danzig (Gdansk) and 110 miles northwest of Warsaw, in what was then Royal Prussia, a region of the Kingdom of Poland. He was named after his father, Niklas Koppernigk, but afterwards followed the academic custom of the time and Latinized his name as Nicolaus Copernicus.

The Koppernigk family were originally German-speakers who migrated eastward to the province of Silesia in the thirteenth century, settling in the town known today as Koperniki, in present-day southeast Poland, close to the Czech border. Around 1350 the family moved to Krakow, capital of the Kingdom of Poland, where Niklas Koppernigk, the astronomer's great-great grandfather, was made a citizen in 1396. The astronomer's father, also named Niklas Koppernigk, first appears in records in 1448 as a prosperous merchant dealing in copper, which he sold mostly in Danzig, the Polish port city at the mouth of the Vistula. Around 1458 he moved from Krakow to Thorn, where a few years later he married Barbara, daughter of Lucas Watzenrode the Elder, a wealthy merchant and city councillor.

The Watzenrodes also originated from Silesia, having taken their name from their native village of Weizenrodau near Schweidnitz, which they left for Thorn after 1360. Lucas Watzenrode the Elder was born in Thorn in 1400 and in 1436 he married Katherina von Rüdiger. Katherina was a widow, having previously been married to Henrich Pechau, a town councillor of Thorn, by whom she had a son, Johann Peckau, who would be like another uncle to the young Nicolaus Copernicus.

Lucas Watzenrode the Elder died in 1462, leaving three children: Barbara, the astronomer's mother; Christina, who in 1459 married Tiedeman Van Allen, a prosperous merchant serving in the last quarter of the fifteenth century eight one-year terms as Mayor of Thorn; and Lucas Watzenrode the Younger, who would become Bishop of Warmia

(Ermeland), the region between Pomerania and Masuria in northeastern Poland, one of the four provinces into which the Duchy of Prussia was then divided, with the Estates of Royal Prussia to its west and the Kingdom of Poland to its south. The Watzenrodes were further related by marriage to wealthy burgher families of Krakow, Danzig and Thorn, as well as prominent noble families of Royal Prussia.

Thorn was founded on the site of an old Polish settlement by the Teutonic Knights, who built a castle there in 1230. Three years later the Grand Master of the Teutonic Knights, Hermann von Salza, together with his associate Hermann Balk, signed the foundation charters for Thorn and the nearby city of Kulm (Chelmno). These were among the seventy places or more in Prussia founded by the Teutonic Knights, each being protected by a castle and often endowed with a church. The sense of security given by these castellated settlements attracted the surrounding farmers, and soon developed into towns and cities with craftsmen and traders, each of the communities surrounded by defence walls and interconnected by roads.

The Teutonic Knights were one of three orders – the others being the Knights Templars and the Knights Hospitallers of St John – founded during The Crusades, their purpose being to aid Christian pilgrims to the Holy Land by building hospices and hospitals for them as well as fighting alongside the crusaders. Their emblem, a black cross on a white field, contrasted with the red cross on white of the Knights Templars and the white cross on red of the Knights Hospitallers.

The Order of the Teutonic Knights was founded at the end of the twelfth century at Acre in the Gulf of Haifa, which had been captured by the army of the Third Crusade in 1191 after a memorable siege. Following the defeat of the Christian forces in the Levant, the Order moved to Transylvania in 1211 to help defend Hungary against an invasion by a Turkic tribe known as the Cumans. Then in 1226 Duke Conrad I of Mazovia invited Hermann von Salza to move his knights into the Baltic region to conquer and Christianize the pagans known as the Old Prussians. Pope Honorius III had already called for a crusade against the Prussians, but this had been unsuccessful and Duke Conrad was thus led to bring in the Teutonic Knights, giving them a large grant of land in Culmerland, the region around Kulm, as well as any territory they might conquer, putting them only under the authority of the Holy See.

The Teutonic Knights slaughtered and enslaved the Prussians and seized their lands, and by the mid-fourteenth century they had taken control of most of the northern tier of what is now Poland. The Kingdom of Poland, much reduced in size because of the incursions of the Teutonic Knights and other powers, began to revive under Casimir III, the Great (r. 1333–70), the last king of the Piast dynasty, which had ruled since the end of the tenth century.

When Casimir began his reign, the Polish economy was ruined and the country depopulated and devastated by continual war. When he died he left a prosperous kingdom that had doubled in size, mostly through the addition of territory in what is today the Ukraine. He had reformed the institutions of the kingdom, sanctioned a code of laws, built many new castles, and, with the permission of Pope Urban V, founded a Studium Generale in Krakow, the first institution of higher learning in Poland. As part of his effort to repopulate the kingdom he encouraged Jews to resettle in Poland in large numbers, protecting them as 'people of the king.' As a result some 70 per cent of Ashkenazi Jews trace their origin to Poland in the time of Casimir the Great.

Casimir had no legal sons, and so he arranged for his sister Elisabeth, Dowager Queen of Hungary, and her son Louis, King of Hungary, to be his successors to the Polish throne. After his death 1370, Louis was proclaimed King of Poland, though his mother Elisabeth was the power behind the throne until her death in 1380. When Louis died in 1382, he was succeeded by his eldest surviving daughter, Mary, who became Queen of Hungary. But the Polish nobility were opposed to a personal union with Hungary, and they chose Mary's younger sister, Hedwig, who on 15 October 1384 was crowned in Krakow as King Jadwiga of Poland, not long after her tenth birthday. (Her official title was 'king' rather than 'queen', signifying that she was a sovereign in her own right and not just a royal consort.)

Two years later Jadwiga was betrothed to Jogaila, Grand Duke of Lithuania, an illiterate heathen who was about 24 at the time. Jogaila had agreed to adopt Christianity and promised to return to Poland lands that had been 'stolen' by its neighbours. Jadwiga had misgivings about the marriage, for she had heard that Jogaila was a filthy bear-like barbarian, cruel and uncivilized, and so she sent one of her knights, Zawisza the Red, to see if her proposed husband was really human. Zawisza reported that Jogaila was beardless, clean and civilized, and

though an unlettered heathen he seemed to have a high regard for Christian culture. Therefore, Jadwiga went ahead with the marriage, which was held in Krakow Cathedral on 4 March 1386, two weeks after Jogaila was baptized. Immediately after the wedding Archbishop Bodzanta crowned Jogaila, who became King of Poland as Wladyslaw II Jagiello, beginning a reign that would last for 48 years. Thus started the illustrious Jagiellonian dynasty, which reigned until 1572; its dynasts ruling as Kings of Poland and Grand Dukes of Lithuania.

Wladyslaw and Jadwiga reigned as co-rulers, and though Jadwiga had little real power she was very active in the political and cultural life of Poland. She led two expeditions into Ruthenia in 1387, when she was only thirteen, and recovered territory that had been transferred to Hungary during her father's reign. Three years later she personally opened negotiations with the Teutonic Knights. Jadwiga gave birth to a daughter on 22 June 1399, but within a month both mother and child died.

Jadwiga was renowned for her charitable works and religious foundations, which led to her canonization as a saint in 1997 by the Polish Pope John Paul II. One of the legacies in her last will and testament provided for the restoration of Krakow's Studium Generale, otherwise known as Krakow Academy, a bequest that was faithfully carried out by King Wladyslaw, creating the institution known today as the Jagiellonian University of Krakow.

A Polish–Lithuanian army broke the power of the Teutonic Knights at the Battle of Tannenberg in 1410. This war ended with the First Peace of Thorn, signed in February 1411. According to the terms of this treaty, the Teutonic Knights held on to most of their territory through the control of their fortified cities and towns, though their subjects grew increasingly rebellious under the harsh rule of the Order.

During the next quarter of a century the Polish Crown fought the Teutonic Knights in a series of three wars that devastated Prussia, though with no territorial loss for the Order. In 1440 the gentry of Thorn joined with other towns to form the Prussian Confederation, which in 1454 rose up in revolt against the Teutonic Knights, beginning the Thirteen Years' War, in which they were aided by Casimir IV Jagiellon, King of Poland and Grand Duke of Lithuania. At the beginning of the revolt the people of Thorn stormed and captured the castle of the Knights and killed or imprisoned its defenders. The rebellion

finally ended on 19 October 1466 with the Second Peace of Thorn. According to the terms of the treaty, the western part of the Order's territory along the lower Vistula came under Polish suzerainty as the Estates of Royal Prussia, which included Thorn and Danzig, while the wealthy see of Warmia became a separate dominion ruled by its bishop under the Polish Crown.

The Teutonic Knights retained only the hinterland of the port of Königsberg bounded on the southwest by Warmia. The Peace of Thorn was reaffirmed on 8 April 1525 by the Treaty of Krakow, which gave the Grand Master of the Teutonic Knights hereditary possession of the Order's territory, then known as 'Ducal Prussia', as a fief of the Polish Crown.

Such was the political chequerboard of the 'remote corner of the earth' where Copernicus was born and spent most of his life. His father had moved to Thorn during the Thirteen Years' War against the Teutonic Knights, and he lent money to the city to help support the soldiers of the Crown who were defending it as well as paying for a bridge across the Vistula, later serving as magistrate and alderman. Copernicus' maternal grandfather, Lucas Watzenrode the Elder, had fought against the Teutonic Knights in the Thirteen Years' War, in which he was wounded. He is listed in the *Thorner Bürger Buch*, the registry of the citizens of Thorn, as a landowner, businessman, judge and councilman, the type of burgher who had formed the core of the resistance to the Order of the Teutonic Knights.

Thorn was a member of the Hanseatic League, an alliance of trading cities and their guilds that held a trade monopoly along the northern tier of Europe from the Baltic to the North Sea. The commercial activities that led to the formation of this alliance originated in 1159 in the northern German port city of Lübeck, 'Queen of the Baltic', after it was rebuilt by Duke Henry the Lion of Saxony. Lübeck became a base for merchants in Saxony and Westphalia to trade farther afield along the coast from the North Sea and the Baltic and up rivers into the hinterland to cities like Thorn and Krakow, forming guilds known as *Hansa*, which bound the member cities to come to one another's aid with ships and armed men. The formal founding of the League came in 1356 at Lübeck, when representatives of the member cities met in the town hall and ratified the charter of the first *Hansetag*, or Hanseatic Diet.

Lübeck and other cities of the League built trading posts called *kontor*, founding them as far afield as the inland Russian port of Novgorod, Bergen in Norway, and London. The London *kontor*, established in 1320, was west of London Bridge near Upper Thames Street on the present site of Cannon Street station. Like Hanseatic *kontors* elsewhere, the trading post in London developed into a walled community with its own warehouses, weigh house, offices, houses and church. Beside the *kontors*, each of the Hanseatic ports had a warehouse run by a representative of the League, those in England located in Bristol, Boston, Bishop's Lynn (now King's Lynn), Hull, Ipswich, Norwich, Yarmouth (now Great Yarmouth) and York. Krakow, Thorn and Danzig had Hansa representatives, the latter becoming the largest city in the League due to its control of Polish grain exports. By the beginning of the sixteenth century, Danzig had a population of more than 35,000, while Krakow, the capital of the Polish Kingdom, had about 20,000 inhabitants and Thorn some 10,000.

A fifteenth-century chronicler describes Thorn in the time of Copernicus: 'Thorn with its beautiful buildings and its roofs of gleaming tile is so magnificent that almost no town can match it for beauty of location and splendor of location.' The population of the city is now 20 times greater than it was in the fifteenth century, but the old walled town on the right bank of the Vistula is almost miraculously preserved, with its many Gothic buildings, all in brick, laid out along the medieval network of narrow streets and around the cobbled main square, still dominated by the Old Town Hall built in 1274 and extended in the late sixteenth century. When viewed from the Vistula the old town is still much the same as it appears in a lithograph done in 1684 by Christoph Hartknoch, lacking only the sailing barges that Copernicus would have seen in his youth, making their way along the river to and from the docks below the city walls.

Nicolaus Copernicus was the youngest of four children, the others being his brother Andreas and his sisters Barbara and Katherina. When he was seven years old, the family moved from Saint Anne's Street to a larger house on the main square of Thorn, where the city's weekly market was held. By that time he had started in the parochial school at the nearby Church of St Johann, whose renown attracted students from all over Poland. There his studies included mathematics and Latin, which

was not only the universal academic language of Europe but was used in the liturgy at the Church of St Johann and spoken by the merchants of the Hanseatic League who traded in Thorn.

King Casimir IV visited Thorn in 1485, accompanied by his court, disembarking from the royal barge beside the main gate of the city, the entire populace there to greet him. Casimir spent six weeks in Thorn, dining in turn at the houses of the various notables, and so the young Nicolaus Copernicus would have met the king several times, for his extended family included the most influential people in the city.

Niklas Koppernigk died some time between 18 July 1483 and 19 August 1485, the former date marked in the last record of his financial affairs, and the latter by a reference to him as deceased. He was buried in the Church of St Johann, where his portrait can still be seen on his funerary monument; a tall, slim figure with a moustache and long black hair, shown on his knees with his hands joined in prayer. His son Nicolaus would have been among the mourners at the funeral, left without a father before he had even entered his teens.

Barbara Koppernigk never remarried, and she continued to live in the house on the market square with her children until she died, passing away some time between 1495 and 1507. Her oldest daughter, Barbara, left the house to become a nun at the Benedictine convent in Kulm. The youngest girl, Katherina, married a merchant from Krakow, Bartholomaeus Gertner, who had moved to Thorn and become a city councillor. The Gertners moved into the Koppernigk house, where their five children were born and they continued to live until at least 1507.

Nicolaus and his older brother Andreas were taken in hand after their father's death by their uncle Lucas Watzenrode, who looked after their education. Lucas had studied at the Jagiellonian University in Krakow in the years 1463–4, after which he went on to the University of Cologne, where he received an MA in 1468. He then completed his education at the University of Bologna, where in 1473 he was awarded a doctorate in canon law.

After receiving his doctorate Lucas returned to Thorn, where he found employment as a school teacher. At the school he became involved with the principal's daughter, described by a contemporary chronicler as a 'pious virgin'. The result of this affair was an illegitimate son named Philipp Teschner, who later became Mayor of Braunsberg

(Braniewo), a town in east Prussia, where he was a prominent supporter of the Protestant Reformation.

Lucas left the school before his bastard was born, giving up teaching and embarking on a career in the Church. The following year he was appointed Canon of Leczyca, a town southeast of Thorn. During the years 1477–88 he worked as a close collaborator with Sbigneus Olesnicki the Younger, nephew of Cardinal Sbigneus Olesnicki the Elder, the most powerful man in Poland after King Casimir IV. Lucas took up residence with Sbigneus the Younger at Gnesen, 60 miles southwest of Thorn. While he was there, he used his influential connections to secure new prebends, or stipends: first the canonry of Wladyslaw in 1478, then Warmia in 1479 and Gnesen in 1485. He was finally ordained as a priest in 1487.

The Second Peace of Thorn in 1466 had removed Warmia from the control of the Teutonic Knights and placed it under the sovereignty of the Polish Crown as part of the province of Royal Prussia, although with special privileges that gave it some degree of autonomy under its bishop. The following year the cathedral chapter of Warmia elected Nicolaus von Tüngen as bishop, going against the wishes of King Casimir IV. The new bishop allied himself with the Teutonic Knights and King Matthias Corvinus of Hungary. This led to a conflict known as the War of the Priests, which began in 1478 when the army of the Polish Crown invaded Warmia, putting the town of Braunsberg under siege. The town withstood the siege, and the war ended the following year with the Treaty of Piotrkow Trybunalski. According to the terms of the treaty, King Casimir recognized von Tüngen as bishop and accepted the right of the cathedral chapter of Warmia to elect future bishops, provided that they were accepted by the Polish king and swore loyalty to him.

On 31 January 1489 von Tüngen resigned because of ill health, and soon afterwards the cathedral chapter elected Lucas Watzenrode as Bishop of Warmia. The new bishop was mitred by Pope Innocent VIII, once again against the explicit wishes of King Casimir, who had wanted the bishopric for his son Frederic. Watzenrode prevailed, and when Casimir died in 1492 the independence of the bishopric of Warmia was confirmed by his son and successor John I Albert.

Bishop Lucas numbered among his close friends several humanist scholars who were leading figures in the Renaissance, most notably

Jan Dlugosz, Conradus Celtes and Filippo Buonaccorsi, all three of whom had graduated from or lectured at the Jagiellonian University of Krakow. The young Nicolaus Copernicus would have met them as well as other learned friends of his uncle, putting him in touch with the humanist movement of the Renaissance at an early age.

Jan Dlugosz (1415–80), a graduate of the Jagiellonian University, was Canon at Krakow and later Archbishop of Lemberg. He too was a protégé of Sbigneus Olesnicki the Elder and wrote a biography of the Cardinal. Dlugosz was tutor to the children of Casimir IV, three of whom, John I Albert (r. 1492–1501), Alexander (r. 1501–6) and Sigismund I (r. 1506–48), would succeed their father in turn as King of Poland. He was sent by Casimir on diplomatic missions to the Papacy and the court of the Holy Roman Emperor, and was involved in the King's negotiations with the Teutonic Knights during the Thirteen Years' War and at the peace negotiations afterwards. Dlugosz is best known for his *Annale seu cronicae incliti Regni Poloniae* (Annals or chronicles of the famous Kingdom of Poland) and *Historiae Polonicae librii XII* (Polish Histories, in 12 books). The first of these works covers events not only in Poland but elsewhere in Europe from 965 up until the author's death in 1480, in which he synthesizes historical information with legends and possibly fiction.

Conradus Celtes (1459–1508) was born in Germany under his original name Konrad Bickel, which he Latinized when he began his higher studies, first at the University of Cologne and then at the University of Heidelberg. After finishing university he gave humanist lectures, first in central Europe and then in Rome, Florence, Bologna and Venice. His first book was *Ars versificandi et carminum* (The art of writing verses and poems), published in 1486. When he returned to Germany, he was brought to the attention of Emperor Frederick II, who named him Poet Lauraeate, after which he was given a doctoral degree by the University of Nuremberg. After making a lecture tour of the Holy Roman Empire, he travelled to Krakow and joined the Jagiellonian University, lecturing on mathematics, astronomy and the natural sciences. In Krakow he collaborated with other poets in founding a learned society based on the Roman academies, the Sodalitas Litterarum Vistulna (Literary Society of the Vistula). Celtes founded other branches of this society in Hungary, Austria and Germany, where he was made a professor at the University of Heidelberg. In 1497 he

was called to Vienna by Emperor Maximilian I, who appointed him Teacher of the Art of Poetry and Conversation, with imperial privileges. This was the first time such an honour had been bestowed. In Vienna he lectured on the works of classical Greek and Latin writers and in 1502 founded the Collegium Poetarum, a college for poets. He was appointed Head of the Imperial Library founded by Maximilian, and collected numerous Greek and Roman manuscripts, his most notable discovery being the *Tabula Peutingeriana*, or *Peutinger Table*, the only known surviving map of the Roman Empire, with annotated itineraries for the aid of travellers. Celtes was working on the publication of the *Peutinger Table* when he died of syphilis in Vienna on 4 February 1508. The disease was then known as '*morbus gallicus*', or the 'French disease', which he had apparently contracted while lecturing in Italy. His most enduring influence was in historical studies, for he was the first to teach the history of the known world as a whole.

Filippo Buonaccorsi (1437–96) was born in San Gimignano in Tuscany. He took the surname Callimachus after he moved to Rome in 1462 and became a member of the Roman Academy of Julius Pomponius Laetus. The paganist views and licentious lifestyle of the academicians led Pope Paul II to have them all arrested in 1467, but they pleaded for mercy and were soon released. Buonaccorsi and other members of the Academy took part in an unsuccessful attempt to assassinate the Pope in 1468, after which he fled to Poland. When the Pope's agents searched the Academy, they found homosexual verses written by Buonaccorsi to the Bishop of Segni, Lucio Fazini. The Pope's persecution of the academicians came to a sudden end when he died of a stroke on 26 July 1471, supposedly while being sodomized by a page boy.

When Buonaccorsi arrived in Poland he first found employment with Gregory of Sanok, Bishop of Lemberg. Later he was hired by King Casimir IV as tutor of the royal children, together with Jan Dlugosz. He was named royal secretary in 1474, subsequently serving as ambassador to the Sublime Porte in Istanbul and then acting as the King's representative in Venice. Buonaccorsi collaborated with Conradus Celtes in founding the Sodalitas Litterarum Vistulna in Krakow. He spent the rest of his days lecturing at the Jagiellonian University of Krakow, as well as writing poetry and prose in Latin. His best known works are biographies of King Wladyslaw III, Cardinal Sbigneus Olesnicki the Elder and Bishop Gregory of Sanok, all of whom had been his patrons.

The cathedral of the Warmia bishopric was at Frauenburg (Frombork), a port town about 100 miles east of Danzig. Not far to the east of Frauenburg was the smaller town of Braunsberg, where Philipp Teschner was appointed as mayor after his father Lucas Watzenrode became Bishop of Warmia. Lucas had always acknowledged his illegitimate son, and so it would seem that he had arranged Teschner's appointment as mayor.

The Bishop's palace was at Heilsberg (Lidzbark Warminski), 140 miles northeast of Thorn, to which Lucas returned as often as he could to visit his family and look after his nephews Andreas and Nicolaus. Lucas had decided that the two boys would follow in his footsteps, beginning as canons in his own cathedral chapter in Frauenberg, for with his powerful position and influential connections he could ease their way to the top of the Catholic hierarchy in Poland, particularly in the case of Nicolaus, for whom he seemed to have had great expectations.

When Nicolaus was 15 his uncle Lucas sent him to the cathedral school at Wloclawek, some 30 miles up the Vistula, where he would be prepared for his higher studies. Most of the teachers at the school were graduates of the University of Krakow, the most notable being Dr Nicolaus Wodka, who Latinized his name as Abstemius. Abstemius was a specialist in gnomonics, the study of shadows cast by a gnomon, the pointer on a sundial, and Nicolaus probably studied astronomy with him. There is a tradition that the sundial on the south side of Wloclawek Cathedral was constructed by Copernicus in collaboration with Abstemius.

After Nicolaus graduated from the school at Wloclawek, he and Andreas were sent by their uncle Lucas to his alma mater, the Jagiellonian University in Krakow. And so, after the arrangements had been made, Nicolaus and his brother set out from Thorn to Krakow in the autumn of 1491, beginning a journey that would eventually bring about an intellectual revolution and change a world view that had been held since antiquity.

CHAPTER 2
A NEW AGE

The latter half of the fifteenth century was the twilight of the medieval period and the dawn of a new era, the Renaissance of Western Europe. In 1453, 20 years before the birth of Copernicus, the Turks captured Constantinople, the capital of the Byzantine Empire and the Christian continuation of the Roman Empire. Two years later the Gutenberg Bible was printed. Nineteen years after Copernicus was born, Christopher Columbus discovered America, opening up a New World at the beginning of a new age.

The European Renaissance was the culmination of a 1,000 years of development that began after the collapse of Graeco-Roman civilization. The Roman Empire had been divided since AD 330, when Constantine the Great moved his capital to the city of Byzantium on the Bosphorus, renaming it Constantinople. The Western Empire finally came to an end in 480 with the death of Julius Nepos, the last Emperor of the West, who was assassinated in Dalmatia, the last remnant of his domain. Thenceforth, the Emperor in Constantinople was sole ruler of what remained of the Empire.

By the end of the fifth century AD the Roman Empire had been reduced to the predominately Greek-speaking East, where Christianity was rapidly supplanting the worship of the ancient Graeco-Roman deities. The heart of the Empire was now Asia Minor, where a Greek was more likely to be called a *Rhomaios*, or Roman, rather than a Hellene, which had come to mean a pagan, while the people of Constantinople referred to themselves as *Byzantini*, or Byzantine, and were Christian. Modern historians consider the end of the fifth century to be a watershed

in the history of the Empire, which thenceforth is generally referred to as Byzantine rather than Roman.

The peak of the Byzantine Empire came under Justinian I (r. 527–65), who reconquered many of the lost dominions of the Empire, so that the Mediterranean once again became a Roman sea. Justinian I also broke the last direct link with the classical past when in 529 he issued an edict forbidding pagans to teach. As a result the ancient Platonic Academy in Athens was closed, ending an existence of more than nine centuries, as its teachers went into retirement or exile.

By the end of the eighth century, after successive invasions by the Persians, Arabs and Slavs, the Empire was reduced to little more than Asia Minor and a few enclaves in Greece, Italy and Sicily. Athens was utterly destroyed by the barbarian Heruli around 590, and was virtually uninhabited for centuries afterwards, while Alexandria was taken by the Arabs in 639, its great library having been destroyed two centuries earlier by a mob of Christian fanatics. The great centres of the ancient Graeco-Roman world had fallen, leaving only Constantinople as a beleaguered bastion of a Christianized remnant of classical civilization.

The Library of Alexandria had preserved the writings of all the Greek writers from Homer onward. After its destruction, all of the original works of Greek philosophy and science were lost, but copies of many of them survived and eventually made their way to Western Europe by a number of routes and through various chains of translation.

The first Greek philosophers of nature had emerged in the sixth century BC in the Greek colonies on the Aegean coast of Asia Minor and its offshore islands, as well as in Magna Graecia, the Greek cities in southern Italy and Sicily. They were known as *physikoi*, or physicists, from the Greek *physis*, meaning 'nature' in its widest sense, for they were the first who tried to explain phenomena on natural rather than supernatural grounds. Now called the Presocratics, they included Thales, Anaximander, Anaximenes, Pythagoras, Xenophanes, Heraclitus, Parmenides, Empedocles and Anaxagoras.

Anaxagoras, one of the last of the Presocratics, was born about 500 BC in Clazomenae, one of the Greek cities on the Aegean coast of Asia Minor, and when he was about 20 he moved to Athens, which emerged as the political and intellectual centre of the Hellenic world

after the end of the Persian Wars in 479 BC, beginning the classical period in Greek history. Anaxagoras was the first philosopher to dwell in Athens, where he became the teacher of Pericles, who, in his famous funeral oration in 431 BC, honoured the Athenians who fell in the first year of the Peloponnesian War. He reminded his fellow citizens that they were fighting to defend a free and democratic society that was 'open to the world,' and whose 'love of the things of the mind' had made their city 'an education to Greece.'

Pericles was referring to the famous philosophical schools of Athens, the most renowned of which emerged in the following century: the Academy of Plato (427–347 BC), who had been a disciple of Socrates (469–399 BC), and the Lyceum of Aristotle (384–322 BC), who been Plato's pupil at the Academy.

Most of the great philosophers and scientists of the classical period taught in Athens, the most notable exceptions being Hippocrates of Kos (460–*c.*370 BC), the father of Medicine, and Democritus of Abdera (*c.*470–*c.*404 BC), who with his teacher Leucippus formed the atomic theory.

Plato believed that mathematics was a prerequisite for the dialectical process that would give future leaders the philosophical insight necessary for governing a state. The mathematical study included arithmetic, plane and solid geometry, harmonics and astronomy. Harmonics involved a study of the physics of sound as well as an analysis of the numerical relations supposedly developed by the Pythagoreans in their researches on music. This led the Pythagoreans to believe that the cosmos was designed according to harmonious principles, as is evident not only in music but in the eternally recurring motions of the heavenly bodies, the eternal 'harmony of the celestial spheres.' Astronomy was studied not only for its practical applications, but for what it revealed of 'the true numbers' and 'true motions' behind the apparent movements of the celestial bodies.

Plato considered that philosophers should approach the study of nature, particularly astronomy, as an exercise in geometry. Through this idealized geometrization of nature, relations that were as certain as those in geometry could therefore be obtained. As Socrates remarks in the *Republic*: 'Let's study astronomy by means of problems, as we do geometry, and leave the things in the sky alone.'

The main difficulty in Greek astronomy was to explain the apparent motion of the stars, the sun, the moon and the five visible planets. These are known as the celestial bodies and they all seem to rotate daily about a point in the heavens, namely the celestial pole, which is caused by the axial rotation of the earth in the opposite direction. Although the sun rises in the east and sets in the west each day, it appears to move back from west to east by about one degree from day to day, hence traversing the 12 signs of the zodiac in one year, which is a phenomenon caused by the orbiting of the earth around the sun.

The apparent path of the sun through the zodiac (i.e., the ecliptic) makes an angle of about 23.25 degrees with the celestial equator, which is the projection of the earth's equator out into space. This is explainable by the fact that the earth's axis is tilted by about 23.25 degrees with respect to the perpendicular of the ecliptic plane, which is an inclination that causes the recurring cycle of the seasons.

The planets all trace paths near the ecliptic, which seems to go from east to west during the night alongside the fixed stars, while from one night to the next they move slowly back from west to east around the zodiac. Each planet also exhibits an apparent periodic retrograde motion, which appears as a loop when plotted on the celestial sphere. This is owed to the fact that in orbiting the sun the earth passes the slower outer planets and is itself passed by the swifter inner ones, in both cases making it appear that the planet is moving backwards for a time among the stars.

According to Simplicius (*c.*490–*c.*560), Plato posed a problem for those studying the heavens: to demonstrate 'on what hypotheses the phenomena [i.e., the "appearances", in this case the apparent retrograde motions] concerning the planets could be accounted for by uniform and ordered circular motions.'

The first solution to the problem was provided by Eudoxus of Cnidus (*c.*400–*c.*347 BC), a younger contemporary of Plato at the Academy. Eudoxus was the greatest mathematician of the classical period, credited with some of the theorems that would later appear in the works of Euclid and Archimedes. He was also the leading astronomer of his era, and had made careful observations of the celestial bodies from his observatory at Cnidus, on the southwestern coast of Asia Minor. Eudoxus suggested that the path of the five planets was the result of

the uniform motion of four connected spheres, all of which had the earth as their centre, but with their axes inclined to one another and rotating at different speeds. The planet is attached to the equator of the innermost sphere, and the outermost sphere moves with the fixed stars. The motions of the sun and the moon were accounted for by three spheres each, while a single sphere sufficed for the daily rotation of the fixed stars, making a total of 27 spheres for the cosmos. Eudoxus' model, known as the theory of homocentric spheres, was elaborated upon by Callipus of Cyzicus (fl. 370 BC), who added two more spheres for the sun and moon and one more for Mercury, Venus and Mars, to make a total of 34 spheres. The theory of homocentric spheres was subsequently adopted by Aristotle as the physical model for his geocentric cosmos, using 55 planetary spheres plus another for the fixed stars.

Aristotle's writings are encyclopaedic in scope, including works on logic, metaphysics, rhetoric, theology, politics, economics, literature, ethics, psychology, physics, mechanics, astronomy, meteorology, cosmology, biology, botany, natural history and zoology. The main outlines of Aristotle's theory of matter and his cosmology derive from earlier Greek thought, which distinguished between the imperfect and transitory terrestrial world below the sphere of the moon and the perfect and eternal celestial region above. He took from Thales, Anaximander and Anaximenes the notion that there was one fundamental substance in nature, and reconciled this with Empedocles' concept of the four terrestrial elements – earth, water, air and fire – to which he added the *aether* of Anaxagoras, the quintessential element, as the basic substance of the celestial region.

According to Aristotle, the fundamental terrestrial substance, which he called *prostyle*, is completely undifferentiated. When this matter takes on various qualities it becomes one of the four terrestrial elements, and through further developments it takes on the form of the things seen in the world. Aristotle would describe this as matter taking on form. Thus, matter is the raw material; form is the collection of all the qualities that give an object its distinctive character. These two aspects of existence – matter and form – are inseparable, and can only exist in conjunction with one another.

Aristotle's cosmology arranged the four elements in order of density, with the immobile spherical earth at the centre surrounded by

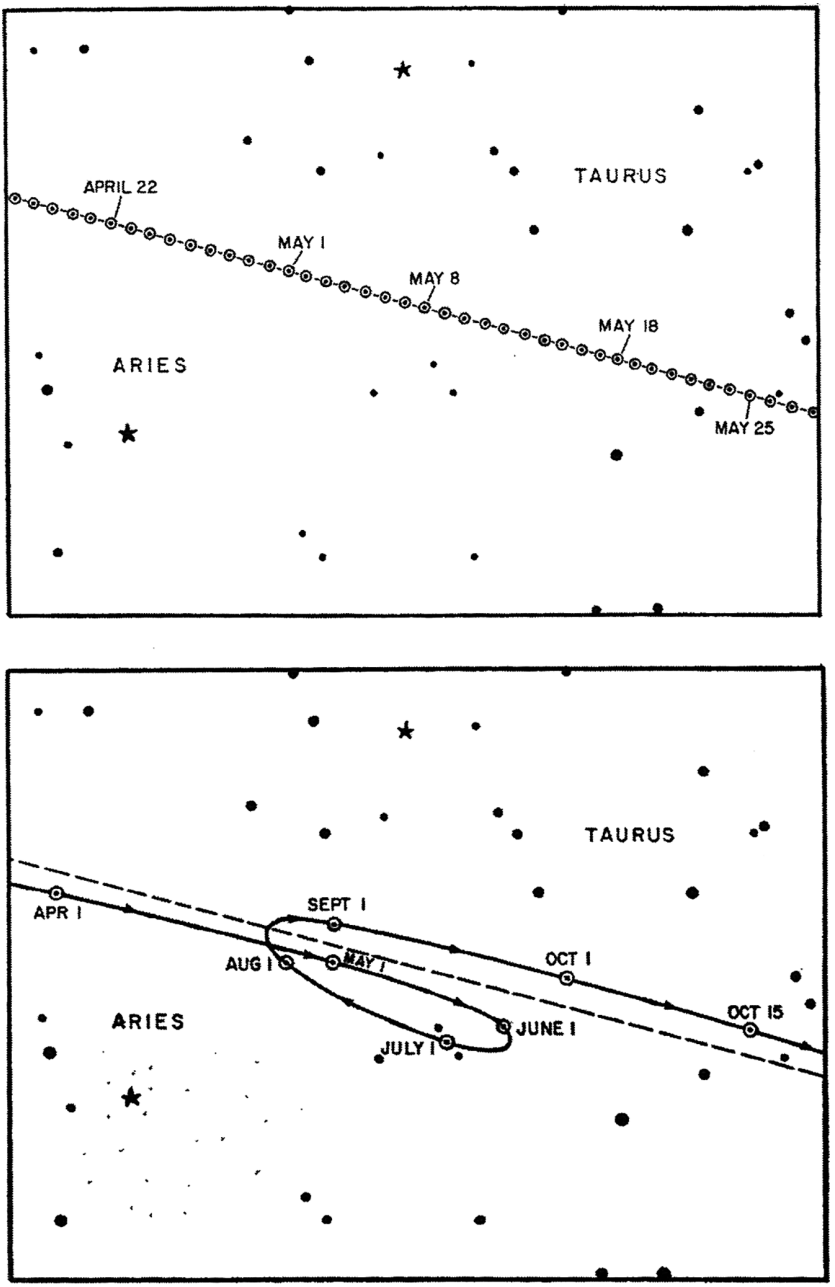

Figure 2 The apparent motion of the Sun through the constellations Aries and Taurus (above); the apparent motion of Mars through the constellations Aries and Taurus (below).

concentric shells of water (the ocean), air (the atmosphere) and fire, the latter including not only flames but extraterrestrial phenomena such as lightning, rainbows and comets. The natural motion of the four terrestrial elements moves towards their natural place, so that if earth is displaced upward in air and released, it will fall straight down, whereas air in water will rise, and so does fire in air. This linear motion of the terrestrial elements is temporary since it ceases when they reach their natural place. Aristotle's theory of motion argues that heavier objects fall faster than those that are light, and Aristotle also argued against the possibility of void. These two theories that we know are erroneous will dominate physics until the seventeenth century.

According to Aristotle, the celestial region begins at the moon, beyond which are the sun, the five planets and the fixed stars, all embedded in crystalline spheres rotating around the immobile earth. The celestial bodies are made of *aether*, whose natural motion is circular at constant velocity, so that the motions of the celestial bodies, unlike those of the terrestrial region, are unchanging and eternal.

Heraclides Ponticus (*c.*390–*c.*339 BC), named this way because he was a native of Heraclea on the Pontus (the Black Sea), was a contemporary of Aristotle, and had also studied at the Academy under Plato. His cosmology differed from that of Plato and Aristotle in at least two fundamental points, which may be due to the fact that after leaving the Academy he seems to have studied with the Pythagoreans. The first point of difference concerned the extent of the cosmos, which Heraclides thought to be infinite rather than finite. A second difference related to the apparent circling of the stars around the celestial pole, which, according to Heraclides, was actually due to the rotation of the earth on its axis in the opposite sense. Simplicius, in his commentary on Aristotle, writes that 'Heraclides supposed that earth is in the center and rotates while the heaven is at rest, and he thought by this supposition to save [i.e., account for] the phenomena.'

Aristotle's successor as director of the Lyceum was his son-in-law Theophrastus (*c.*371–287 bc), to whom he gave his enormous library, including copies of his complete works. Theophrastus headed the Lyceum for 37 years, during which time he reorganized and enlarged it, making him regarded as the second founder of the Lyceum.

More than 200 works, which are now mostly lost, are attributed to Theophrastus, whose interests was as encyclopedic as that of Aristotle. Theophrastus is known as the father of Botany thanks to his two extant works: *History of Plants* and *Causes of Plants*. His treatise *On Stones* marks the beginning of geology and mineralogy. His work on human behaviour, entitled *Characters*, is a witty description of the types of people living in Athens during his time, all of whom still seem to be represented in the modern city.

Two other schools of philosophy were founded in Athens late in the fourth century BC. These were not formal institutions like the Academy and the Lyceum, but more loosely organized groups gathered to discuss philosophy. One of the schools, known as the Garden, was founded by Epicurus of Samos (341–270 BC) and the other, the Porch, was established by Zeno of Citium (*c.*335–263 BC). The name of the first school came from the fact that Epicurus lectured in the garden of his house, while the second was named for the Stoa Poikile, or Painted Porch, in the Agora, the meeting place of Zeno and his disciples, the Stoics. Both Epicurus and Zeno created comprehensive philosophical systems that were divided into three parts – ethics, physics and logic – in which the last two were subordinate to the first, whose goal was to secure happiness.

The physics of Epicurus was based on the atomic theory, to which he added the new concept that an atom moving through the void could at any instant 'swerve' from its path. This eliminated the absolute determinism that had made the original atomic theory of Leucippus and Democritus unacceptable to those who, like the Epicureans, believed in free will. Zeno and his followers rejected the atom and the void, for they looked at nature as a continuum in all of its aspects – space, time and matter – as well as in the propagation and sequence of physical phenomena. These two opposing schools of thought about the nature of the cosmos – the Epicurean atoms in a void versus the continuum of the Stoics – have competed with one another from antiquity to the present, for they seem to represent antithetical ways of looking at physical reality.

After the death of Alexander the Great in 323 BC, the beginning of the Hellenistic period, the intellectual centre of the Greek

world shifted from Athens to Alexandria, the new city that he had founded on the Canopic branch of the Nile. Alexandria became the capital of a powerful kingdom ruled by Ptolemy I (r. 305–280 BC), founder of the Ptolemaic dynasty that ruled Egypt for nearly three centuries.

The emergence of Alexandria as a cultural centre was largely due to the establishment of a school of higher studies known as the Museum, called thusly because it was dedicated to the Muses. The Museum and its famous Library were founded by Ptolemy I and further developed by his son and successor Ptolemy II (r. 283–225 BC). By law the Library was required to obtain a copy of every work written in the Greek world, and by the time of Ptolemy III (r. 247–221 BC) it was reputed to have a collection of more than half a million parchment rolls, including everything written from Homer onward.

The first scientist to head the Library was Eratosthenes of Cyrene (*c.*275–*c.*195 BC), and to draw a map of the known world on a system of meridians of longitude and parallels of latitude, which, together with observations with a gnomon, allowed him to make an accurate estimation of the earth's circumference.

Eratosthenes was a friend of Archimedes (*c.*287–212 BC), who dedicated to him the famous treatise *On Method*. Archimedes, who was from Syracuse in Sicily, probably studied at Alexandria under the pupils of Euclid (fl. *c.*295 BC), whose great work on geometry, the *Elements*, he quoted from extensively.

One of Archimedes' works, *The Sand-Reckoner*, mentions a revolutionary astronomical theory proposed by his older contemporary Aristarchus of Samos (*c.*310–287 BC), writing that

> Aristarchus of Samos has, however, enunciated certain hypotheses in which it results from the premises that the universe is much greater than that just mentioned. As a matter of fact, he supposes that the fixed stars and the sun do not move, but that the earth revolves in the circumference of a circle about the sun, which lies in the middle of the orbit, and that the sphere of the fixed stars, situated about the same center as the sun, is so great that the circle in which the earth is supposed to revolve has the same ratio to the distance of the fixed stars as the center of the sphere to its surface.