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Sky and TELESCOPE

In This Issue:

Nicholas Copernicus—
The Man and His Work

The Case of
the Willamette

A Tribute to Copernicus

Air and Sea and Sky

★

Vol. II, No. 7

MAY, 1943

Whole Number 19

20 cents

★

Nicholas Copernicus
(1473-1543)

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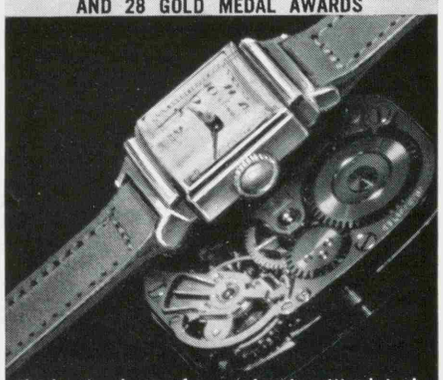

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Sky and TELESCOPE

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The Editors Note . . .

THIS month we commemorate the 400th anniversary of the death of Copernicus, thereby paying tribute to a man, an astronomer, and a country. Leader in planning the celebration is the Kosciuszko Foundation, an organization devoted to furthering cultural and intellectual relationships between Poland and the United States.

The multicolored cover design on this issue, portraying the great astronomer, Copernicus, and drawn by Arthur Szyk, has been reproduced through the courtesy of the Kosciuszko Foundation from the same five-color process plates that were used in printing the cover of the little volume, **Nicholas Copernicus, 1543-1943,** by Stephen P. Mizwa, reviewed in **Sky and Telescope** last month.

The artist is a Polish refugee, who has done striking work in caricature and in portraying outstanding Polish and American personalities. As described in the book, the cover shows Copernicus as churchman, scholar, and astronomer. The chain and cap are academic symbols. In his left hand he holds a device illustrating the Copernican theory, with the sun at the center of the solar system. In front of him is an enlarged fragment of the Jagiellonian golden globe.

In the upper left-hand corner is Wawel, the Polish Acropolis, with the center of Kraków as it looked in Copernicus' student days (1491-95). The coat-of-arms of the University of Kraków appears at the upper right, with the Roman numbers (1364-1400) indicating the years when the University was founded and renovated, respectively. On the table is the Holy Bible. The lantern is such as he used on his observation tower at night.

The lower border bears the Polish white eagle of the Jagiellonian period (red and white are Polish national colors). On the other borders are the coats-of-arms of Gniezno, first capital of Poland (left), of Kraków, capital of Poland in the astronomer's student days (right), of Torun, Copernicus' native city (top).

Highlight of Copernican celebration activities will be the meeting in Carnegie Hall, New York City, on May 24th. His Excellency, Jan Ciechanowski, ambassador of the Republic of Poland to the United States, will take part, and many of our foremost American astronomers are scheduled to speak. Dr. Harlow Shapley, national chairman of the Copernican Quadricentennial Committee, will preside. Information regarding this meeting may be obtained from the Kosciuszko Foundation, 149 East 67th Street, New York City.

On the occasion of the quadricentennial, the Foundation will begin its preliminary and preparatory work toward the post-war educational reconstruction of Poland, especially toward rehabilitation of the destroyed university libraries. The Foundation hopes that "thus, the commemoration of a great Polish scientist of distant past may become a call to the living to pass on a torch of light to those of the future."

Among the books on cultural topics pertaining to both countries which the Foundation has been instrumental in publishing is the one from which our front cover is reproduced. This book is available from the Foundation in a popular edition, pamphlet bound, at 75 cents, and in a cloth cover at $1.50. A limited number of prints of the color cover, on heavy 11x14 paper, are available at $1.00 each.

There has been wide interest in the book and its contents. The **Journal** of the Royal Astronomical Society of Canada says: "Filled with authoritative facts and adorned with numerous reproductions of rare portraits and historic scenes . . . the valuable publication is recommended to the many friends of Poland and of astronomy." Otis Peabody Swift, of **Time,** has written: "A perfectly magnificent volume on Copernicus. I have seldom seen a better done brochure." And the editor of **Scripta Mathematica,** Jekuthiel Ginsburg, writes: "It is beautiful in form and in spirit and it will form a must addition to the Library of any scholar interested in the life of Copernicus and the history of Mathematics and Astronomy. It is a most dignified tribute to the memory of the great Polish astronomer."

On behalf of our readers, we gratefully acknowledge the magnificent cooperation of the Kosciuszko Foundation in so generously providing the plates and assisting in the arrangements for printing the beautiful cover of this Copernican issue of **Sky and Telescope.**

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IN MAY, 1943, the entire civilized world commemorates the passing away 400 years ago of the man who reversed the direction which astronomy had taken from the earliest times. By shattering the naive and common-sense notion that the earth is an inert, stationary mass, and by demonstrating that, on the contrary, the earth is a planet in motion, Nicholas Copernicus initiated the modern phase in the development of the science of the heavens.

Twenty years after the Turks brought the Byzantine Empire to an end by their capture of Constantinople in 1453, the child was born who was destined to overthrow the astronomical system that had held sway even longer than the 1,000-year-old Byzantine Empire. In the flourishing merchant city of Thorn, or Torun, on the banks of the Vistula River in northeastern Europe, in the heart of a fertile agricultural region, the founder of modern astronomy first saw the light of day in 1473.

About his infancy and childhood we know practically nothing, except that when he was only 10 years old, his father died. The loss of this parent, who had been a prosperous businessman and a municipal official, might have been a severe blow. But his mother's brother had entered the service of the church, and in the course of the years rose to be head of the virtually autonomous bishopric of Ermland or Varmia in Polish Prussia. The bishop, whose name was Lucas Watzelrode, took a fatherly interest in his nephew, watching over him carefully and smoothing his path.

In fact, the career which Nicholas adopted followed in the footsteps of his maternal uncle. Thus, when he was ready to begin his higher education, he entered the University of Kraków at the age of 18. Like his uncle before him, for several years he studied the liberal arts at that renowned Polish institution,

Nicholas Copernicus on the observation tower at the Cathedral of Frauenberg, by Jan Matejko (1838-93), the Polish national painter. Courtesy, the Kosciuszko Foundation.

NICHOLAS COPERNICUS

The Man and His Work

By Edward Rosen

College of the City of New York

then the foremost school of Eastern Europe. But upon his return home he was sent across the Alps, where he spent the next decade (1496-1505) at various Italian universities. Lucas Watzelrode had also gone to Italy as a young man; by a coincidence he received the doctoral degree in law from Bologna University in the very year in which Copernicus was born. Lucas had gone on to become a canon of Frauenburg, a town in the Ermland diocese that was situated on the coast of the Baltic Sea; and after his elevation to the rank of bishop, he procured his nephew's appointment in 1497 as a canon in the very chapter to which he had belonged. In these three important respects, then, the outward life of Copernicus was patterned after his uncle's: undergraduate study at Kraków, graduate work in Italy, and ecclesiastical service as a canon.

This church office carried an assured annual income for life. But a heavy part of the price that had to be paid for such enviable security in a turbulent and unsettled society was the vow of celibacy, a promise never to marry. It is sometimes erroneously stated that Copernicus became a priest; but as a matter of fact he never took holy orders. On the other hand, he was no monk, either; for he never joined any of the regular monastic brotherhoods.

The canons attached to a specific church were organized in a body known as a cathedral chapter, through which they administered their affairs. From the cathedral chapter of Frauenburg Copernicus sought and obtained leave of absence to continue his studies at the famous Italian universities. Those were the years when Italy was the intellectual center of Europe. Students were attracted to it from far and wide. Floods

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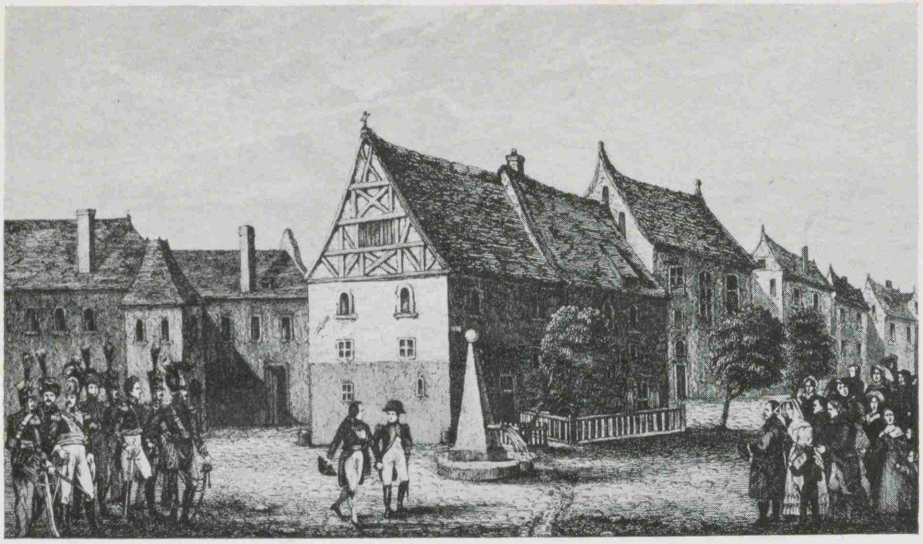
BACK COVER: Two pieces of the Willamette (from the collection of Mr. and Mrs. J. Hugh Pruett) which were taken from different parts of the meteorite, show different types of etching. (See page 6.)



When Napoleon visited Torun, Copernicus' birthplace, in 1807, he was surprised that no monument had been erected to honor the astronomer. Courtesy, the Kosciuszko Foundation.

of excellently printed books poured from its busy presses. Brilliant works of art were executed by architects, sculptors, and painters of high talent. From neighboring lands momentous voyages of discovery were conducted both eastward and westward, across the vast Indian Ocean to the Far East and over the uncharted Atlantic to the New World. A lively and contagious curiosity inflamed men's minds. The stirring achievements of Columbus and da Gama, da Vinci and Michelangelo, contributed to the formation of a new intellectual climate, the Renaissance.

In this invigorating atmosphere Copernicus spent 10 fruitful years. He had promised to make himself more useful to his chapter by mastering medicine. But although he attended the universities of Bologna, Padua, and Ferrara, listening to lectures on the healing art and on law, his first love was the study of the heavens. His earliest recorded observation was performed at Bologna in 1497; and from that time forth he remained a persistent watcher of the skies. He evidently made something of a reputation as an astronomer, for in the jubilee year of 1500 he was invited to deliver a lecture at Rome before a large audience of students and specialists in the science. Having enjoyed a full decade of intimate contact with humanist culture, and having earned a diploma as Doctor of Both Laws, that is, both canon law and civil law, Copernicus made the long trip home to take up his duties as a canon.

Now that his prolonged student days were over, his first assignment was the congenial task of living at the residence of his uncle, Bishop Lucas, in the interior of the diocese. His functions were to assist the bishop and guard his health. Six quiet and productive years ensued, during which Copernicus' first publication appeared. While he had been in Italy, the well-known Aldine Press in Venice had issued a collection of Greek letters. From this volume he selected the epistles of a Byzantine historian and, translating them into Latin, had them printed at Kraków, at that time the capital of the kingdom of Poland. He dedicated the slender work to his uncle, the bishop. This little linguistic exercise, curiously enough, was the only thing written by Copernicus, to the printing of which he attended personally. Only two of his other writings, the *Trigonometry* and the *Revolutions,* went to press during his lifetime, and in each case the manuscript was simply put into the hands of friends by the astronomer, who was already well along in years. All his other papers were first printed in relatively recent times.

Early in 1512, Bishop Lucas set out for Kraków to attend the wedding of the king of Poland. From that ill-fated journey he never returned. After the death of his uncle, Copernicus proceeded to Frauenburg, the seat of the cathedral chapter, where he spent the next four years.

While he was in his forties and therefore still in full possession of his physical vigor, he was charged with the arduous responsibility of administering the outlying landed estates owned in common by the chapter. In 1520, armed bands of Teutonic Knights, with the support of troops drawn from Germany, invaded the peaceful villages of Ermland, burning, pillaging, destroying, and killing. Frauenburg, too, got its taste of the *furor Teutonicus* or *Schrecklichkeit.* Artillery and emergency provisions were rushed to Copernicus, who was in command of the fortress of Allenstein or Olsztyn, "this bulwark of our entire diocese," as one of his colleagues called it.

One of the consequences of the war was an acute financial crisis. His experience as an administrator had inevitably brought the money question to Copernicus' attention, and he had formulated some theoretical principles and practical suggestions for dealing with a depreciated currency. After the Teutonic Knights were repulsed and peace was restored, his statesmanlike proposals were set forth at an assembly of the Prussian Diet, which he attended as a delegate of his chapter. His presentation was valued so highly that he was repeatedly sent to subsequent meetings as personal representative of his bishop. Although certain of his recommendations were incorporated in a currency decree issued by the Polish crown, the clash of conflicting selfish interests blocked a completely satisfactory treatment of the situation.

A fellow canon complained to Copernicus that his essay on currency reform was somewhat obscure. Copernicus began his reply with the following remarks: "It is of no small importance to be able to throw light on matters that by their very nature are wrapped in thick fog. But it is also possible for a man who perceives the truth to be unable to express it. This, I fear, sometimes happens to me." And he closed his discussion of the topic with this comment: "I acknowledge that I may be wrong. I am only one man, and I have only one mind, and I am unaware or ignorant of what others regard as more useful proposals."

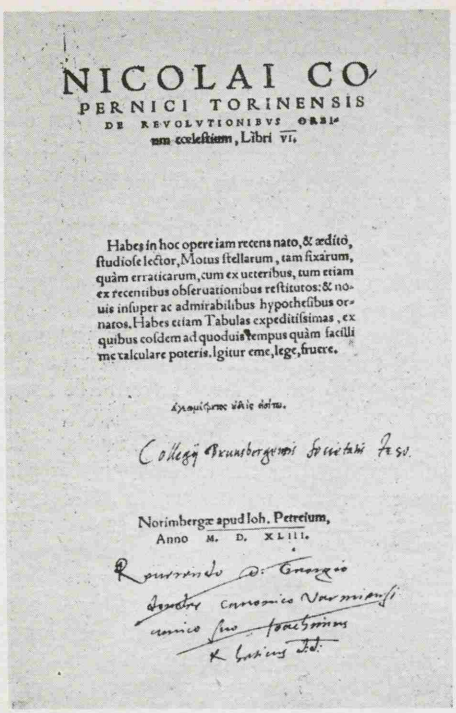
By this time Copernicus was approaching his 60th year, and administrative and ambassadorial functions were regularly assigned to his more youthful colleagues. Freed from these onerous burdens, he could devote a greater proportion of his time and energy to the dominating interest of his life, the study of astronomy. In particular, he concerned himself with the perplexing problem of correcting the calendar. The western world was still operating under the calendar that had been promulgated by Julius Caesar; and it was widely recognized that the defects of the Julian calendar urgently needed repair. "Not so long ago," Copernicus tells us in the preface to his *Revolutions,* "under Leo X the Lateran Council considered the question of reforming the ecclesiastical calendar. The problem remained unresolved then only because it was felt that the lengths of the year and month and the motions of the sun and moon had not yet been adequately measured. From that time on . . . I directed my attention to a close study of these topics." Continued efforts at reform throughout the 16th century culminated in the replacement of the Julian calendar by the Gregorian, which regulates our lives today. The Gregorian calendar, instituted in 1582, was to a considerable extent based upon Copernicus' computations and conclusions.

In observing the heavens he suffered from a severe handicap. Attention to his duties forced him to do most of his

stargazing at Frauenburg, which was not the most suitable location in the world for an observatory. With manifest envy he tells us in the *Revolutions* that "the ancient observers had the benefit of a clearer atmosphere, for they say that the Nile does not give rise to fogs, such as we get from the Vistula. Nature has denied that advantage to us, the inhabitants of a more rigorous climate, where fair skies are rare and the high latitude permits Mercury to be seen only infrequently." From this passage it is evident that there is no basis for the statement sometimes encountered that Copernicus never laid eyes on the planet Mercury.

Although the difficulties imposed by a harsh natural environment were undoubtedly serious, they were not as important as they might be to a modern astronomer, who must often make unremitting observation of the same body night after night. It was customary in Copernicus' time to make crucial, rather than continual, observations. When an effort was being made, for example, to determine one element of a planetary orbit, the planet would be observed and careful measurements taken on several successive nights, and then not again, perhaps, for a considerable interval. When we think of Copernicus as an observer, we must of course bear in mind that he did his work during the period of naked-eye observations, since the telescope was not introduced until some 60-odd years after his death.

The story of the closing years of his life and the publication of his theory has already been sketched in The SKY, September, 1940; abstracts of this note are appended here.[1] We turn our attention to what is without doubt the most significant aspect of his immortal treatise, *On the Revolutions of the Celestial Spheres*. Early in his career Copernicus became convinced that the prevailing system of astronomy was fundamentally unsound. For almost 14 centuries the views of Ptolemy had reigned supreme. Although minor trends did develop in other directions, in all that time no one had ever successfully challenged the Greco-Roman astronomer of Alexandria.


NICOLAI CO
PERNICI TORINENSIS
DE REVOLVTIONIBVS ORBI
um coelestium, Libri VI.

Habes in hoc opere iam recens nato, & æditò, studioſe lectior, Motus ſtellarum, tam fixarum, quàm erraticarum, cum ex ueteribus, tum etiam ex recentibus obſeruationibus reſtitutos: & nouis inſuper ac admirabilibus hypotheſibus ornatos. Habes etiam Tabulas expeditiſsimas, ex quibus coſdem ad quoduis tempus quàm facilli me calculare poteris. Igitur eme, lege, fruere.

Collegij Brunsbergensi Societatis Jesu

Norimbergæ apud Ioh. Petreium,
Anno M. D. XLIII.

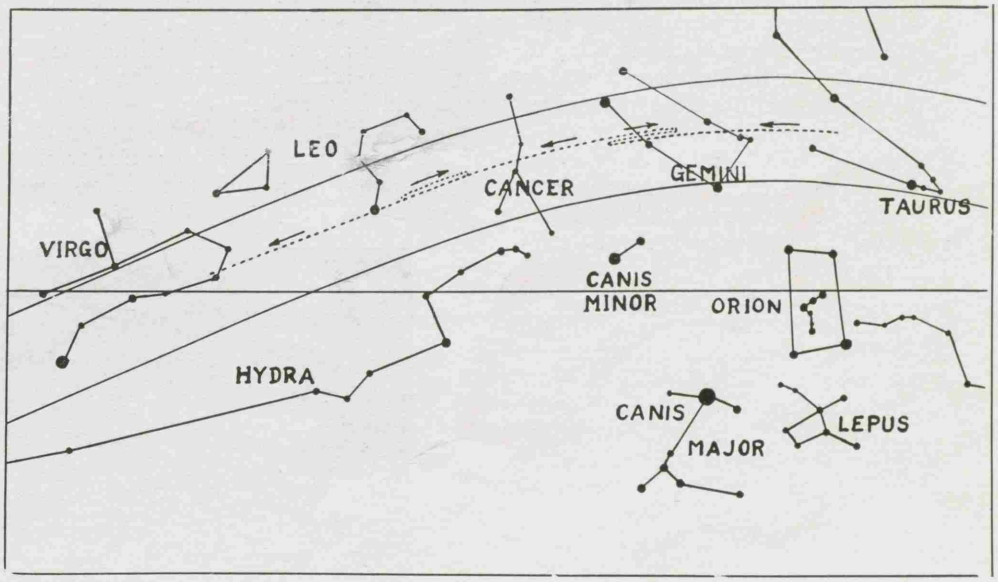
The title page of "De Revolutionibus" (first edition). This copy of the book was apparently donated to the Jesuit College of Brunsberg, in Varmia. Courtesy, the Kosciuszko Foundation.

In the Ptolemaic system the earth was regarded as stationary. Therefore it was firmly believed that the sun really rose each morning in the east, climbed overhead, and set in the west. For this account of the situation, which seems to be solidly based on the plain testimony of our senses, Copernicus simply substituted a daily rotation of the earth.

In a similar way, the traditional doctrine held that the planets, moving eastward most of the time, annually slowed down until they actually came to a halt, then reversed themselves and traveled westward for a brief period (retrograde motion), stopped and reversed themselves a second time, resuming their eastward journey, and repeating this cycle of changes endlessly. But Copernicus assigned to the earth an annual orbit about the sun. According to his version of the matter, we view the entire heavenly ballet from a huge observatory, the earth, that is itself in motion. The planetary movements which astronomers trace so carefully are in fact compounded of two ingredients, the real motion of the planets and the real motion of the earth. The annual revolution of the earth about the sun is reflected in the observed movements of the other members of the solar system. The planets do not really reverse the direction of their motion; their motion is always directed in the same sense at a nearly constant rate.

By establishing the fact that the earth is a moving planet and by introducing the concept of relative motion in the interpretation of the heavenly scene, Copernicus overthrew the Ptolemaic system and laid the foundations of modern astronomy. Great as this accomplishment was, it must not be exaggerated. For one thing, Copernicus still clung to the traditional belief that the path of a heavenly body must be a circle or a combination of circles. The discovery that the orbits are elliptical had to wait for Kepler. Again, Copernicus never seriously investigated the causes of planetary motion. He traced the path, but neglected the force. In short, he dealt with the geometry but not with the physics of celestial motion. That gap was closed by the genius of Isaac Newton.

Yet if we look with steady gaze down the long vista of time and visualize the growth of astronomical thought from its groping beginnings to the present day, do we not justly feel a deep debt of gratitude to the destroyer of outworn orthodoxies, the builder of the heliocentric system, the founder of modern astronomy, Nicholas Copernicus?



This chart of the apparent motion of Jupiter from 1942 to 1945 illustrates the annual retrograde movement which the ancients found so difficult to explain, but which presents no problem at all to the Copernican theory.

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[1] **Abstracts from "The Copernican Theory — How it was first presented to the world,"** by Edward Rosen.

IN 1540 there appeared the first printed exposition of Copernicus' heliocentric system. The book was written by an enthusiastic young man, George Joachim Rheticus, who gave up a teaching job in a German university in order to visit the celebrated astronomer and master the new system at its source.

(*Continued on page 14*)

The Case of the Willamette

By J. Hugh Pruett, *University of Oregon*

"METEORITES, though not imbedded in the earth, are real estate, and consequently belong to the owner of the land on which they are found. . . . Seeing there is no error in the record, the judgment of the circuit court will be affirmed."

Speaking was Chief Justice Wolverton of the supreme court of Oregon in the case of the Oregon Iron and Steel Company vs. Ellis Hughes; the date was July 17, 1905.

Three years earlier on a wooded hillside (property of the plaintiff) near Willamette, Ore., the defendant had discovered a curious mass of metal — almost 16 tons of it. Later he moved it onto his own land. When the real nature of this find became known, the plaintiff brought suit to recover and won a decision in the lower court. The defendant appealed to the higher court, but was there finally forced to abandon his claims to the huge chunk of nickel-iron which was later famous as the Willamette meteorite, the largest object of its kind ever found throughout the vast expanse of the United States and Canada.

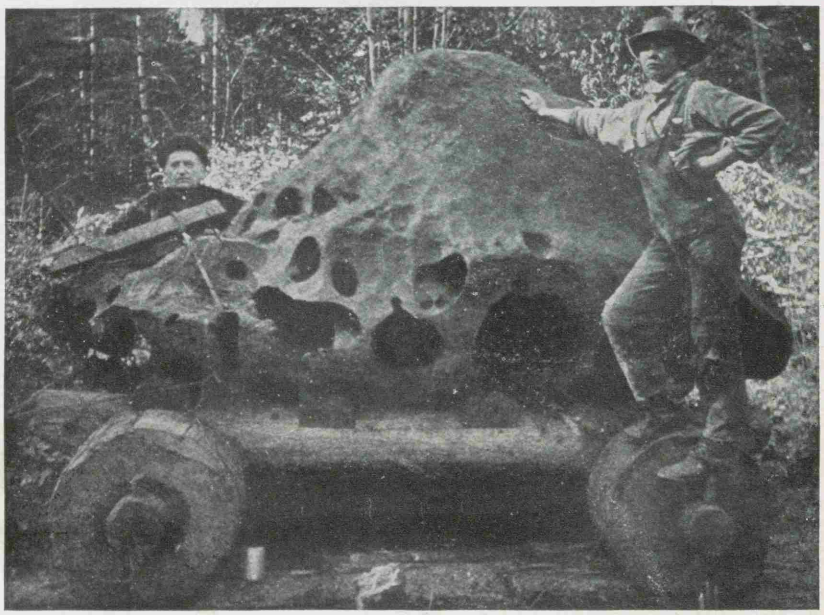
To the day of his sudden death, December 3, 1942, at the age of 83, Mr. Hughes considered this decision an inglorious and unjust defeat. This sturdy, intelligent Welsh woodsman, who lived his last 50 years less than a mile from the spot of the Willamette's discovery, probably never realized that his lasting honor in scientific circles far overbalanced the loss of the mere material possession of the meteorite.

In July, 1938, a party from the University of Oregon visited the scene of discovery, interviewed Mr. Hughes and others familiar with the early history of the event, and obtained many valuable photographs. At that time Mr. Hughes seemed in good health, and very graciously told Betty Jane Thompson, the journalist of the visiting group, many details not found in earlier published accounts.

"I was coming home," said Mr. Hughes, "from where I had been cutting wood for the Willamette school. I noticed this big rock for the first time but didn't think anything of it. The next day I saw a very rusty broken saw near it. I sat down on the rock which was very flat and about 18 inches above ground. Bill Dale came along.

"Then I picked up a white stone and started to hammer on the rock. It rang like a bell. Dale said he bet it was a meteor. It would probably be there yet, but my wife — you know how women are — had ideas. She was afraid somebody would go up and get it the next day."

After months of urging by his wife, Mr. Hughes went to work on a crude truck with which to move the huge mass to a spot near his house three quarters of a mile away. He trusted no one to help him aside from his wife, his 15-year-old boy, and his horse. He made the truck of logs and mounted it on ungainly wheels sawed from a tree trunk. Long and tiring work with levers and blocking was required to get the object elevated above the ground level. Finally, when it was sufficiently raised, the meteorite flopped over and tumbled onto the truck flat side down. Mr. Hughes thrilled at the fond remembrance. "It couldn't have been done better if you'd laid it there with your own hands."



The Willamette meteorite, as it appeared while Mr. Hughes was transporting it through the woods on a truck with wheels made from a tree trunk. The nose of the meteorite is upward. Engraving from the "American Museum Journal."

Mr. Hughes next set up a "Spanish windlass" which he securely anchored with a chain. One end of a 100-foot cable of braided wire connected with the truck; the other wound on the barrel of the windlass as his horse walked in a circle around it. Thus a relatively small force exerted by the horse resulted in an immense pull on the cable.

Then began the long haul. The ground was soft, and board tracks had to be laid and relaid. The windlass had to be moved and re-anchored each time the 100-foot cable was wound on it. So great were the difficulties that some days the truck was scarcely moved more than its own length.

During the process of moving, a neighbor chanced by. The next day a newspaper reporter from the Portland *Oregonian* appeared, but found the meteorite covered with burlap. He insisted on a view of the object, but the covering was not removed. Mr. Hughes said with a twinkle in his eye, "When he asked why I wouldn't, I explained the sun might warp it."

After three months of hard work in the forest, during which time few outside the Hughes family knew what was taking place, the meteorite reached its desired destination. When it was at last safely housed in a wooden building on the Hughes property, it was put on display for an admission fee of 25 cents. People from far and near flocked to see the curiosity.

As luck would have it, among those who paid admission was a lawyer from the company on whose property the meteorite was found. "He offered me $50 for the whole piece," said Mr. Hughes, "and said he wanted to show it at the Buffalo World's Fair. I wouldn't listen to him."

Not long after the attorney's visit, suit was filed by the landowners for possession of the meteorite. Public sympathy throughout the trial was generally with Mr. Hughes. The defense advanced the claim that the mass had originally been the property of the Clackamas Indians, had finally been abandoned by them at the spot where found in 1902, and therefore was not necessarily part of the land. Two old Indians, one of the Wasco tribe and the other a Klikitat, appeared in court in substantiation of this claim. Their testimony ran as follows:

The meteorite, Tomanowos, had orig-

inally fallen from the moon and was thought to possess magical powers. It was held in high regard by the Indians. Rain collecting in its hollows was considered "holy water," and into this the Clackamas tribe dipped their arrows before going to war. Their young warriors were initiated by being compelled on the darkest of nights to climb the hill and visit the lonely spot where the celestial visitor reposed.

The account of a somewhat similar litigation was well aired in court by the plaintiff. This was the case of the Winnebago meteorite in Iowa. The tenant on the property saw the meteorite fall — it was comparatively small — and bury itself three feet deep. The next day he dug it up and assumed ownership. Later he sold it. The landowner brought suit and after several years the court granted possession on the ground that such objects belong to the "owner of the soil upon which they fall."

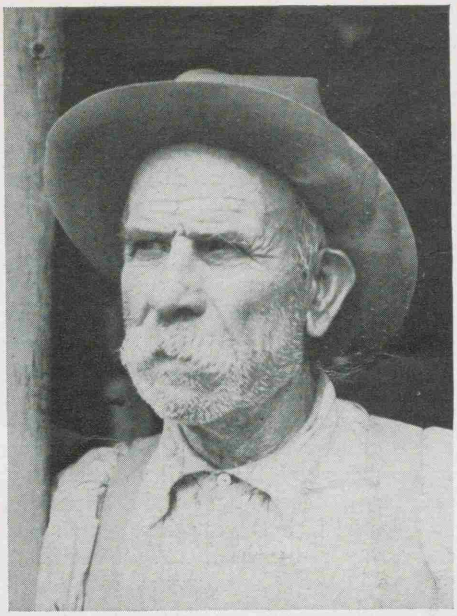
The defense, however, held that there was a marked distinction between the Iowa and Oregon cases. In the former, both sides agreed on the place of fall; in the latter, no one knew where the body had originally landed. The Indians might have moved the meteorite from some other spot in order to give it a place of prominence on the hill. Or, in prehistoric times when water covered the Pacific slope, the metallic mass, together with granite boulders lying near it, might have floated from a distant region on an ice floe. In the language of geologists, it would thus be an erratic, similar to many large granite masses now found in fields and other places where they do not seem to belong.

Finally the circuit court granted possession to the Oregon Iron and Steel Company. The latter soon hauled the contested object from the Hughes property, but got no farther down the road than the Johnson house when Mr. Hughes' appeal to the supreme court stopped further movement. Mr. Johnson, father of Harold Johnson, who still resides in the same locality, was then appointed to guard the meteorite against removal or theft of any parts of it.

Harold Johnson tells that during the many months the mass remained there, the family's sleep was often disturbed by souvenir hunters.

"Today with acetylene torches it might be an easy matter to cut a piece without much disturbance, but in those days the only tools were saws and hammers, and the meteorite would ring like a bell when struck. Often in the middle of the night the 'bell' would clang. Then out of bed jumped father, grabbed his gun and, muttering to himself, rushed outside to start the intruder on his way. I still have a small chunk which father took from a fellow who almost got away with it."

Before the meteorite was placed under guard, small specimens were cut off by various persons. At the request of the National Museum in Washington, Dr. A. W. Miller, Oregon geologist, inspected the huge mass. In a subsequent article, in the Portland *Oregonian* of June 2, 1912, he described his study of the celestial visitor and mentioned that he removed several pieces. Dr. Henry A. Ward, Rochester scientist, made a trip across the continent to study the object. He also obtained several specimens.



Ellis Hughes, discoverer of the Willamette meteorite, as he appeared in 1938. Photo by David Hunter.

At last came the 3,000-word decision of the Oregon supreme court in which the lower court was upheld. After this, the Willamette was taken by water to Portland. From the river it was hauled by 12 powerful horses to the Lewis and Clark Exposition grounds where it was exhibited during the few weeks remaining of this fair.

Scientifically minded Oregonians hoped that this interesting meteorite might remain in the state. But a very tempting bid came from Mrs. William Dodge II, of New York, to whom it was sold on February 15, 1906. Mrs. Dodge presented it to the American Museum of Natural History of New York. It was delivered to this museum April 14, 1906, and placed on exhibition June 7th of the same year. One condition prescribed by the donor was that the main mass should be kept intact in one piece. This weighs 31,107 pounds according to the museum catalogue. In addition, the museum has four other pieces which were evidently removed before Mrs. Dodge's purchase.

In June, 1938, the American Museum, through the kindness of Dr. Clyde Fisher, sent to the University of Oregon on an open exchange a beautiful etched slab of the Willamette, "in order that your school may have a part of the great meteorite found in your state." In addition to this, small specimens are owned by various Oregon residents related to the Hughes and Johnson families and through purchase from them in the past.

Harold Johnson reports that several residents around Willamette who think they have pieces of the meteorite are badly mistaken. The children of the families most closely connected with the historic object were often asked for specimens by their schoolmates. Finding themselves receiving considerable attention, these children obtained pieces of slag from a smelter and passed them out to the unsuspecting who have since cherished them as genuine.

It is generally known that when etched with nitric acid the polished surfaces of pieces from various parts of the Willamette show two distinct types of crystalline figures. The meteorite is classed as a medium octahedrite. Parts of it etch in the long bands characteristic of this class; other parts present a sort of crazy-quilt pattern. Some people assume that this is due to the way the crystals have been cut: crosswise or lengthwise with the grain, but several authorities, including Dr. H. H. Nininger, believe the meteorite has crystallized differently in different places. John D. Buddhue offers this:

"If the direction of cutting were the explanation, I should expect the same structure in other meteorites. The only thing I know of that resembles it at all is the Murn Peowie meteorite from South Australia."

The two different types of etching are well illustrated by the back-cover picture this month, which shows two pieces in the author's collection which were taken from different parts of the meteorite.

The composition of the Willamette is approximately 92 per cent iron and eight per cent nickel. There is disagreement among scientists as to the origin of some of the holes in it, especially those on the rounded side. The cause of the immense cups on the flat side, uppermost when found, is pretty well agreed upon, however. It is thought that mineral matter softer than the main mass originally filled these cavities, but was gradually weathered out during the centuries the meteorite lay on the ground.

When the University of Oregon party visited the Willamette vicinity in 1938, great courtesy was shown the members by the owner of the discovery site, H. S. Crocker, who was operating a fox farm there. The depression from which the meteorite was taken is quite evident. In this hole several pieces of the original underlying rust were found still intact. These contain abundant nickel.

Although our university has only a small slab of the real meteorite, it does, however, have on display on the campus a "life-size" plaster model of the Willamette. This has such a surface finish and color that many people who do not read carefully the attached description go away believing they have seen the actual celestial visitor.

ASTRONOMICAL ANECDOTES

ERRORS OF PTOLEMY'S ALMAGEST

IN MARCH, we discussed briefly the origin of Bayer's material incorporated in his *Uranometria,* and last month something about Ptolemy's star catalogue was set down in this department. The reason for this is that I recently had occasion to glance at Bayer's chart of Centaurus, and was somewhat dismayed to find many of the bright stars very poorly placed. And I am surprised to find a left-handed Orion, with his back toward us; it seems that Bayer wasn't quite consistent in his representations of the constellation figures as seen from the earth, and in the instance of Orion he showed the figure as it would appear from the outside, while the stars are placed as seen from the inside. Or have we made Orion right-handed, and turned him about, since Bayer's day?

The northern constellations of Bayer should be better represented than the southern ones, for Tycho's observations were pretty good. Certainly those given by Ptolemy, whether made by him or Hipparchus or someone else, leave something to be desired. I have had students sketch constellations from the sky, establishing the scale of the large dimensions with a rude cross-staff, and their errors hardly exceed those of the *Almagest,* supposedly derived from careful measurement. I refer here not to the error discussed last month regarding the epoch 138 A.D., for we know that that is not the date for the positions listed.

When all of Ptolemy's longitudes are diminished by 2° 40′, they are reduced to the epoch of Hipparchus, according to Ptolemy's own word and according to the studies of Peters and Knobel. (The small difference of three minutes of arc may be neglected.) Peters and others have computed the positions of the *Almagest* stars for the epoch of Hipparchus (about 130 B.C.) from modern catalogue positions, corrected for precession and proper motion. When these values are compared with the ones derived as above, something like the proper measure of the errors is obtained.

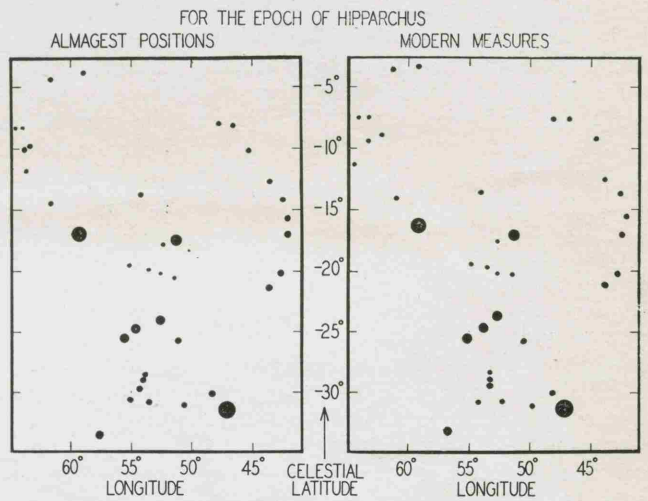
For the zodiacal stars alone, the average errors in celestial longitude range from about 25′ too small to about 13′ too large, depending on the longitude. In celestial latitude, for these same stars, the errors range from 22′ too small to 22′ too large. The errors in both longitude and latitude are periodic, and indicate some maladjustment of the instrument used to measure the positions. A study of this was projected by Peters, but he died before being able to carry it out. Incidentally, the instrument used was an armillary sphere—I have a description of it, and hope to make a model of it.

The errors given above are averages, taken for the stars nearest the ecliptic; hence, they should be least. Some of the largest errors we find near the poles of the ecliptic. If we consider a given constellation—Centaurus, say—we find errors in longitude ranging from 3° 07′ too large to 4° 05′ too small and errors in latitude ranging from 1° 11′ too large to 4° 54′ too small! It was this kind of error that Bayer was forced to copy, more than 14 centuries later. In Centaurus, however, he has corrected some of the errors, perhaps from the observations of the Dutch navigator Pieter Dirchsz Keyser (Latinized as Petrus Theodori), who gave Bayer the material for the south circumpolar groups not observed by Ptolemy or his predecessors.

Even in Canis Minor, where Ptolemy lists only two stars, the longitude difference is wrong by 18′ and the latitude difference by 13′. These values, as do the ones given above, depend of course on the accuracy of the adopted values in the final catalogue of Peters and Knobel. It is possible, but not very likely, that the manuscript written by Ptolemy himself (or Hipparchus) might show smaller errors. There is surprisingly good agreement among the various manuscripts for most of the stars, however, so it is not likely that many of these errors would be diminished if we had the original copy of the catalogue.

I listed the range of errors by constellation, then arranged the constellations in their rank from worst to best. The worst is Centaurus; the best is Canis Minor. No. 31 on this list (which includes 48 constellations) is Orion; that means that it is one of the better-than-average ones, as far as the errors are concerned. The accompanying diagram compares the Ptolemy positions with the true positions, both for the epoch of Hipparchus; it will give some idea of the kind of error tolerated by Ptolemy.

R. K. M.



The true positions of the stars in Orion in Hipparchus' day may be obtained from modern measures corrected (backward) for proper motion and precession. At the right, these positions are compared with those plotted from the positions given in Ptolemy's catalogue, showing very noticeable errors in several instances.

(Below) A portion of the famous Orion, as he appears in Bayer's "Uranometria."

NEWS NOTES

By Dorrit Hoffleit

SEISMOLOGY IN MEXICO

Mexico is witnessing an unprecedented event in our history: the birth and growth of a volcano. Now there is a cone about 1,000 feet high on what was a flat cornfield only a few months ago. Eruptions have been occurring about 14 times a minute with such noise that conversation three miles away must be shouted to be heard at all. Curiously, all this followed almost immediately upon arrangements between United States scientists and the Mexican government for the establishment of a seismograph station at Tonanzintla, where the new national astrophysical observatory began operation about a year ago. A Benioff vertical seismometer has been obtained through the efforts of the National Research Council and the Geophysical Committee of Harvard University. Tests were made at Weston College.

Early in April, the governor of the state of Puebla and the Mexican ambassador visited the Boston area, including its scientific and military institutions. Discussions of earthquakes and volcanoes played a leading role in the entertainment of the visitors, who brought invitations to some of our own astronomers and physicists to attend a conference in Puebla in May, when the seismometer will be officially installed.

AMERICAN PHILOSOPHICAL SOCIETY

The meetings of the American Philosophical Society, held at Philadelphia April 22nd to 24th, celebrated a pair of 200th anniversaries: the birth of Thomas Jefferson and the anniversary of the proposal by Benjamin Franklin "for forming the American Philosophical Society for promoting useful knowledge among the British Plantations in America."

Thomas Jefferson was president of the society for five consecutive terms. Known best for his political achievements, he had likewise a keen interest in the sciences, including astronomy. For example, his observations of the annular eclipse of 1811 may be found in the *Memoirs* of the American Academy.

DURING THE SIEGE OF LENINGRAD

A report sent by radio to the American Association of Scientific Workers by the Soviet Scientists' Antifascist Committee tells about some of the work carried on by Leningrad astronomers during the siege of the city. Although most scientific research institutions were being evacuated and they were being urged to do likewise, 16 members of the Leningrad Astronomical Institute decided to remain and continue with their observations despite the blockade. Thus they succeeded in preparing a series of almanacs for 1943 for astronomers, geodetic workers, navigators and pilots. Their former astronomical almanac has been enlarged so that it now replaces the nautical almanacs issued in other countries. The plates for the almanacs were taken by plane to Moscow for publication by the Academy of Sciences of the U.S.S.R. Work on the almanacs for 1944 had already begun at the time of this communication, February 12, 1943.

SECTION D VICE-PRESIDENT

Dr. Otto Struve, director of Yerkes and McDonald Observatories, has been elected vice-president of Section D of the American Association for the Advancement of Science. This is the astronomy division of the association.

JAMES RICHARD JEWETT

On March 31st, James R. Jewett, professor emeritus of Arabic at Harvard, amateur astronomer and patron of astronomy, died in Cambridge at the age of 82. It was Prof. Jewett who sponsored the building of Harvard's 24-33-inch Schmidt-type telescope. He also donated his own 9-inch Clark refractor with clock drive and housing to Harvard College Observatory, where it fills a great need in the entertainment and instruction of visitors on open nights, especially on school nights. A close friend of Annie J. Cannon, his last gift has been to aid the publication of the Annie J. Cannon memorial volume which will contain Miss Cannon's work unpublished at the time of her death two years ago.

Prof. Jewett will long be affectionately remembered at Harvard as one of its staunchest friends, and by the association of his name with the work accomplished by means of his telescopes.

"BIRDS OF A FEATHER"

On March 1st, 30 astronomers attended an impromptu get-together at the Science Service building in Washington, D. C., by courtesy of Director Watson Davis. Dr. Harlow Shapley, who had pondered on how many astronomers were in the vicinity of Washington doing war work, found seven colleagues who had gone there directly from Harvard College Observatory. Several others had at some time worked or studied at Harvard. Distinguished among those present were Herbert R. Morgan, of the U. S. Naval Observatory, R. d'E. Atkinson, of the Royal Observatory at Greenwich, Father Paul McNally, director of Georgetown University Observatory, and Wallace J. Eckert, head of the U. S. Nautical Almanac Office.

A GOOD PRECEDENT

Unlike the greater portion of the grounds about the U. S. Naval Observatory, one hillside section has the right kind of soil for gardens, according to experts of the U. S. Department of Agriculture. This section will be divided into small plots for those members of the observatory staff who desire to supplement their ration points with home-grown beets and tomatoes.

The superintendent of the Naval Observatory is setting a good example. Astronomers, look to the grounds about you! Before it is dark enough to start observing, and at sunrise before you go to bed, are fine times for invigorating and profitable gardening!

FOUND: LOTS OF VARIABLES

Eight hundred seventy four new variable stars are reported in seven papers just published in the *Annals* of Harvard College Observatory. The great majority of these stars are fainter than magnitude 13 and brighter than 16 at maximum. They were found as a result of systematic searches in seven comparatively small areas (about 8 x 10 degrees), chiefly in the southern hemisphere of the sky, and *not* in the densest parts of the Milky Way. Of these stars, 339 are members of the nearby system, the Small Magellanic Cloud; the others belong to our own galaxy. A large number of the new variables are presumably over 20,000 light-years distant.

A RAPIDLY EXPANDING ATMOSPHERE

A remarkable star has been observed and studied by Dr. Paul Merrill, of Mt. Wilson Observatory. The star, of the 10th magnitude in the constellation Auriga and known as HD 242257, is classified by Miss Cannon as of spectral class *G*0. This implies that its temperature and average characteristics are much like those of our own sun.

Especial attention was attracted to the star when Mt. Wilson spectra revealed a hydrogen line, Hα, in emission. It is extremely rare for a *G*-type star to show emission lines. Further investigation enabled Dr. Merrill to state that hydrogen in the star's atmosphere is streaming outward at a rate of over 300 miles a second. Such large velocities of expansion are usually observed only in the explosive novae. Dr. Merrill suggests that the forces producing these high-velocity outward motions may be of the same nature as those causing the rapid rise of eruptive prominences from the sun's surface.

Amateur Astronomers

A SAILOR SIGHTS A COMET

By Francis A. Wilmot, *Qm. 3c, U.S.N.R.*

IT WASN'T a periscope wake nor a streak from a Stuka that sent a thrill through me on the starry night of February 25th somewhere on the Atlantic. It was the sudden glimpse of a celestial stranger — a wisp of greenish-white light in the familiar constellation, Ursa Major. Without first verifying it by telescopic aid, I immediately concluded it to be a comet. The telescope (or "long-glass," to be nautical) proved this to be correct, for a tail could be seen, almost six degrees long, pointing toward *x* Ursae Majoris. The nucleus was bright and concentrated, with the coma wrapped around it to a diameter of about 15 minutes. Comparisons with neighboring stars showed the comet to have a magnitude of about 3½.

The officer of the deck notified the captain that "the ship's head astronomer had just discovered a comet." Of course, I myself knew that I could hardly be the original discoverer, for the object was already quite prominent. It must have been known for several weeks. But, with due respect and apologies to Dr. Whipple, for the ship it was known as "Wilmot's comet."

After the first excitement of sighting this comet without *a priori* knowledge of it, I commenced the task of plotting its position and course. However, not having adequate star charts on board, other than the simple navigational star chart, it was necessary to draw one myself. With the ship rolling and pitching, even slightly, with the sea, the task was difficult and required exacting and repeated observations. Nor could it be expected that accuracy could be attained. After observations on several successive nights, I did manage to chart about 40 stars down to the 9th magnitude. Upon the background of these stars I fixed the position of the comet from night to night.

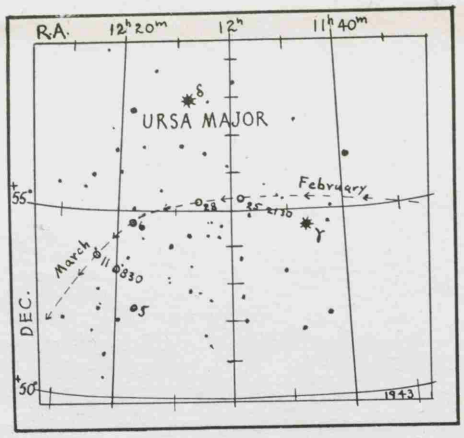
Was it approaching or receding? Had it already passed perihelion? About what was its distance? Well, I next set about to ascertain some of the answers to these questions. It required only two or three days' observation to conclude that the comet was already on its return journey to the depths of space far remote from the sun. The apparent brightness of the comet seemed to be rapidly falling off and at the same time the tail was disappearing. By March 2nd the comet was about as bright as a 4.5-magnitude star and the tail was reduced to about 2½ degrees. At times I seemed to get the impression that there might have been two or three short, stubby tails present.

The comet showed relatively slow proper motion. Using a modified form of a law of average, I calculated that it was moving across our line of sight at the rate of about 1.5 to two miles per second. By averaging the angular motion for every three days, I found the comet changing its position on the celestial sphere by the following amounts:

For	the	first	3	days	26′.25	per	day
"	"	next	"	"	24′.25	"	"
"	"	"	"	"	18′.70	"	"
"	"	"	"	"	20′.00	"	"

Combining the two facts, small proper motion and rapid diminution of apparent brightness, led to the conclusion that the comet's real motion must be mostly along our line of sight, receding from the sun.

A clearer picture of this situation can be realized when the relative positions in space of the comet, earth, and sun, are considered. On March 11th at 08-30 G.C.T., the comet's position was approximately R.A. 12h 24m and Dec. + 53° 50′, at which instant the sun was at S.H.A. 9° 27′ and Dec. — 4° 00′. Thus, the hour circles of these objects were nearly opposite, putting the earth between the two. The comet, therefore, was well outside the earth's orbit. Also,



The author's chart of Whipple's comet, observed and plotted while under way on the Atlantic.

during this interval it was moving somewhat in the same direction as the earth, which accounts, partly, for the small relative velocity in proper motion. Another interesting point to speculate about was the fast disappearance of the comet's tail. From the above explanation, it can be seen that the comet could still have a formidable tail, but due to perspective and the fact that comet tails always point away from the sun, it was seen greatly foreshortened.

This report of course offers no new information, but the whole thing proved rather thrilling, and fills me with some pride. Even under adverse conditions of warfare, an amateur astronomer was able to "discover" the comet, and make difficult observations of it.

AMATEUR ASTRONOMERS ASSOCIATION
New York City

The only meeting of the association this month will be the regular annual meeting on May 19th, when motion pictures will be shown, and the reports of officers and committees heard. There will also be the usual election of members to the Board of Directors, and other business of the society.

Persons interested in membership and the varied program of summer activities should communicate with the secretary, George V. Plachy, American Museum of Natural History, New York City.

NEW YORK AMATEUR WEDS IN TUNISIA

The New York Amateur Astronomers Association and its Optical Division are proud of one of their members, Lt. Bertram Froehly, formerly a Bronx bachelor, but now a Tunisian bridegroom. His bride, Lt. Elaine Bost, may some day learn all about telescopes, although right now she is an Army nurse.

Bert, as his friends know him, entered the Air Corps two years ago, reached Tunisia via Georgia and England. His bride followed the same path, and they were married on February 6th. Prior to that, on January 18th, Pilot Froehly was wounded in action, apparently not seriously.

News of these events reached Bert's mother via the War Department and letters from her son, but the world heard the story from Lowell Thomas and read it in New York newspapers.

DETROIT ASTRONOMICAL SOCIETY

The Detroit society, jointly with the Friends of Polish Arts Society, will hold its Copernican celebration on Saturday, May 22nd, at 8 p.m., in the Rackham Educational Memorial auditorium, which seats 1,000 persons. Dr. Everett R. Phelps, of Wayne University, will give the main address. Other speakers will be Dr. W. Carl Rufus, of the University of Michigan, and the Polish consul, who will introduce Prof. Jersy Kaulbersz, former professor of physiology at the University of Kraków, Poland. Prof. Kaulbersz is to speak in both Polish and English. There will be appropriate choruses by Polish nationals in costume. A large number of Detroit citizens of Polish descent are expected to attend.

BURNHAM ASTRONOMICAL SOCIETY

The second annual banquet of the Burnham Astronomical Society was held in the La Salle Hotel, Chicago, on March 24th. Miss Florence Farrar was the vocalist, and Dr. Oliver J. Lee, of Dearborn Observatory, was the guest speaker.

Because the government has taken over the Congress Hotel, the Chicago amateurs have had to move their meeting place to the La Salle Hotel, at La Salle and Madison Streets, where the regular meetings are scheduled for the second and fourth Tuesdays of each month from September to June.

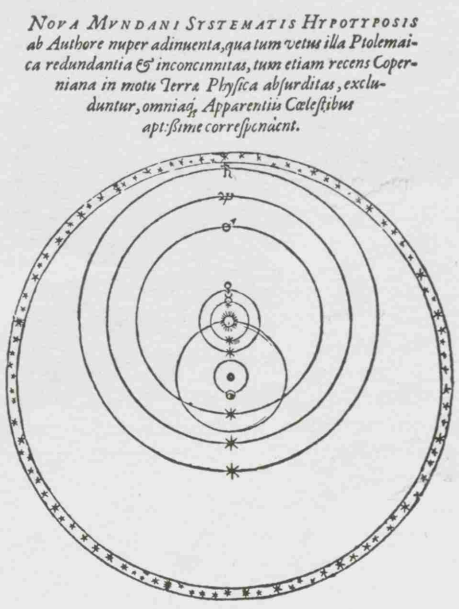
A TRIBUTE TO COPERNICUS

By Maud W. Makemson, *Vassar College Observatory*

THE revolutionary hypothesis of a heliocentric universe gave an impulse to scientific thought that has gathered momentum with the centuries. A seed germinating in unfriendly soil, it thrust slowly upward through the mists of religious bigotry into the pure atmosphere of science, reaching ever toward the eternal stars; and its roots shook the immobile earth to its foundations. The central stem flowered brilliantly in the gravitational astronomy of Newton and reached fruition in the celestial mechanics of the 18th century; but its lesser branches, precise observational and descriptive astronomy, were none the less essential to complete the harmonious whole.

Looking backward over four centuries, some may wonder at the length of time required for the new system to become firmly rooted in the minds of men. Probably no scientific theory was ever so widely discussed or so passionately and bitterly contested by its opponents and defenders over so long a period. More than a century after the publication of *De Revolutionibus,* Father Riccioli wrote a book in which he produced 40 *new* arguments in behalf of the heliocentric theory and 77 against it.

The objections to the theory were tangibly associated with everyday experience; the arguments in its favor were abstract, nebulous, and unsatisfactory. The concept of a moving earth conflicted with common sense. Even today when the earth's rotation has become commonplace, a considerable effort of the imagination is required to visualize the vast and stable earth whirling like a top as it rushes through space



with the speed of a cannon ball without destroying all life on its surface. Copernicus pictured a kind of "natural" motion which left the exterior of the sphere undisturbed, and his opponents unconvinced. He also pointed out that the far vaster crystal sphere of the fixed stars would be in much graver danger of flying to pieces if it revolved, as they insisted, around the earth.

In the second place, the hypothesis of a stationary sun was at variance with the Bible. What better proof could be found that the sun was habitually in motion than the statement that Joshua commanded the sun to stand still? Thus, Catholic and Protestant alike were necessarily aligned against the new teaching.

The scientists were disturbed by the undoubted fact that no annual oscillation of the stars was observed. Although Bruno had rashly argued for an infinite universe as early as 1585, even Tycho Brahe and Kepler firmly believed that the stars were attached to the surface of a crystalline sphere which marked the boundary of space. If, therefore, the earth describes an orbit about the sun, the stars in a given region of the sky should appear brighter and farther apart when the earth is closest to them, and fainter and more compact six months later when the earth approaches the opposite point of its path. Since no such parallactic motion was observed, Copernicus was compelled to expand the radius of the celestial sphere to such a vast extent that the earth's orbit became immeasurably small in comparison. The vacuous immensity thus interposed between the solar system and the starry heavens was considered extremely wasteful by Tycho Brahe, who remained an opponent of the heliocentric system to the end.

The hypotheses of a rotating and revolving earth are susceptible of exact observational proofs, but such proofs were forced to await the slow development of precise methods of measuring small angles on the celestial sphere and the evolution of a new science of mechanics. The minute effect of stellar parallax was eventually detected by Bessel in 1838 by a method proposed by Galileo; but in the persistent search for this proof through the centuries, astronomy was enriched by a succession of remarkable discoveries which the world assimilated reluctantly. The rotation of the earth on its axis was first

(Above) The diagram shows Tycho's concept of the universe. The earth is at the center, but the planets revolve around the sun—all inside a sphere of stars of limited size.

(Right) Tycho Brahe, the greatest observer before the invention of the telescope.

(Left) Johannes Kepler, Tycho's successor, who formulated the three laws of planetary motion.

demonstrated by the Foucault pendulum experiment in 1851.

Let it not be thought that a theory of the cosmos springs fully perfected from a single mind. The strength and beauty of the Copernican system lay in the fact that it contained the elements of growth and development which will not have reached completion until the origin of solar systems and galaxies and other controversial problems of the present day have been satisfactorily explained in the far distant future. During the first half century after its inception, the theory was generally accepted as a simplified method of calculating the positions of sun, moon, and planets for the annual almanacs which were in demand as the basis for astrological predictions. In 1551, Erasmus Reinhold published his "Prussian Tables," derived by the new system, and they immediately superseded the less accurate Alphonsine Tables based on the Ptolemaic theory. Before the close of the 16th century, however, four men were born who were destined to carry on the work of Copernicus in a manner which would stir men's minds and souls to their depths, and revolutionize their concepts of the universe, although only two of them were ardent defenders of the system. They were Tycho Brahe, born in 1546; Galileo, in 1564; Kepler, 1571; and Descartes, 1596.

Tycho Brahe became the most assiduous observer of the heavens that the world had yet produced. His thoughts were first turned to astronomy by the solar eclipse of 1560. In 1563 he observed a close conjunction of Jupiter and Saturn, and noted that neither the Alphonsine Tables nor those of Reinhold had predicted it exactly, the former being wrong by an entire month, the latter by several days. Although impressed by the necessity for continuous and systematic observations, he was not ready to begin his own great program until 1576.

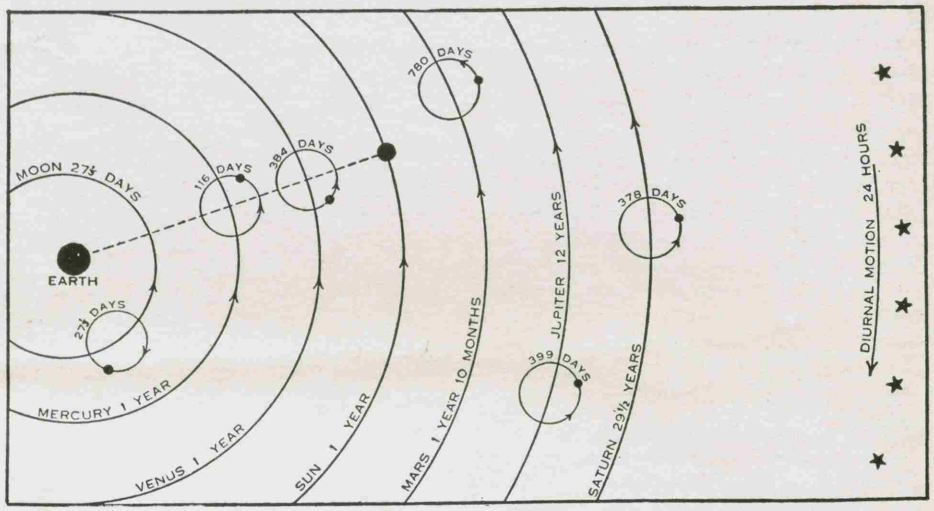
A brilliant new star appeared in Cassiopeia in 1572, which shook Tycho's faith in Aristotle, who had pronounced the heavens unchangeable and incorruptible; for the nova had no measurable parallax and obviously belonged among the fixed stars. Yet the classical teaching held so firm a grasp on the times that Tycho immediately wrote a treatise in which he argued that planets were carried around the earth by revolving crystalline spheres, and comets were generated in the earth's atmosphere.

As if in answer to this challenge, the comet of 1577 trailed brilliantly across the orbits of the inner planets. Tycho measured the parallax, a difficult feat on account of the motion, and concluded that the object was at least three times as far away as the moon and probably beyond the distance of Venus. As the years passed and he followed the bright comets of 1580, 1582, and 1585, his convictions gradually gave way before the evidence of his observations, and he was moved to write a book about these strange visitors from trans-planetary space in which he reasoned that they revolved in orbits about the sun and were not part of the earth's atmosphere. Although he thus abandoned the crystal planetary spheres, Tycho could not reconcile himself to a moving earth. He devised a compromise between Aristotle and Copernicus, in which the planets revolved around the sun, which carried them in an annual orbit about the centrally located earth. Any motion of the inert and heavy earth he dismissed summarily as "contrary to physical principles."

Tycho's observations continued until his death in 1601, seven years before the invention of the telescope. Johannes Kepler, whose almanac for 1595 had gained him an unwarranted reputation as an astrologer and prophet, joined the Danish astronomer at Prague a few months before his death. Kepler has been derided as a mystic, three fourths of whose work was valueless; but his insistent conviction of the divine harmony of the universe, combined with a boundless imagination and a scientific integrity not contented with half measures, enabled him, after years of failure and discouragement, to discover the true laws of planetary motion. Perhaps the dying plea of Tycho Brahe, that his life's work might not have been in vain, gave strength in the darkest hours of Kepler's arduous search.

When Kepler assumed his heritage, he found that Mars stood four or five degrees from the place predicted by the tables of Reinhold. Copernicus once remarked that he would be more than satisfied with his theory if it represented the positions of the planets with an accuracy of 10 minutes of arc, about 1/30 the distance between the Pointers of the Big Dipper. Tycho Brahe's observations with the great mural quadrant attained the surprising accuracy of one or two minutes of arc. So Kepler set out to improve the Copernican system for Mars, until the large discrepancy between observation and prediction was removed. For years he juggled epicycles, equants, and eccentrics of various sizes to attain the desired end. At one point he succeeded in building a structure which reduced the discrepancy to only eight minutes; but steadfastly refusing to accept a result which he considered unworthy of the foundation laid by Tycho, he discarded this system and began once again from the beginning.

At last his perseverance was crowned with success. He saw that the vagaries of Mars could be completely explained within the accuracy of the observations on the assumption that the planet moved in an ellipse with the sun at one focus.



In the Ptolemaic system, the planets moved in large deferents around the earth in their respective sidereal periods, and in small epicycles in their synodic periods, thereby attempting to account for their apparent retrograde motions.

Aristotle's declaration that only the circle was sufficiently perfect to become the path of a celestial body now followed the crystalline planetary spheres into the rubbish heap. Kepler was also able to show mathematically why there are fewer days in the period of the year from autumnal to vernal equinox than there are between the vernal and autumnal equinoxes, that is, why the earth moves fastest in its orbit in midwinter when nearest the sun. This reason was stated in his second law: Every planet moves in such a way that its radius vector sweeps over equal areas in equal intervals of time. The third or harmonic law, relating the squares of the periods of revolution of the planets with the cubes of their mean distances from the sun, led directly to the inverse square law of universal gravitation, formulated by Newton nearly a century later. The *Epitome of Copernican Astronomy,* published by Kepler in 1618, applied his new laws to all the planets and the moon, as well as to the satellites of Jupiter.

In 1609, Galileo turned his rude tele-

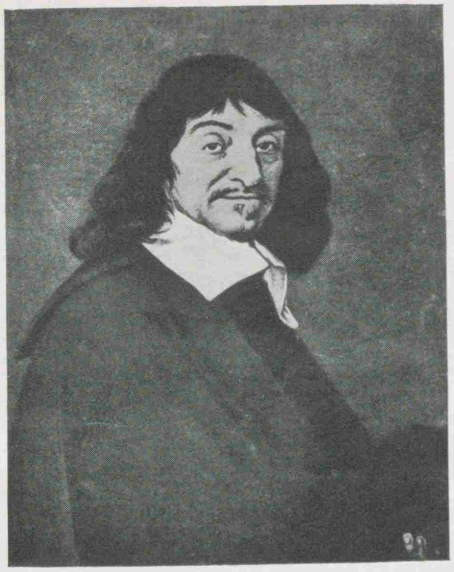
scope skyward and discovered an entirely undreamed-of aspect of the universe. To those who were willing to see, the perfection of the cosmos on which Aristotelians had insisted for 2,000 years became no longer tenable. The moon's smooth spherical surface was found to be marred by mountains and pitted by innumerable craters. In the Milky Way, countless stars were visible where there should have been empty space. The glowing Venus revealed waxing and waning phases exactly like those of the moon, proving that it shone only by reflected sunlight and was indeed a satellite of the sun.

Four tiny spheres were seen to perform endless revolutions about Jupiter like children playing around their parent; and the planet continued to pursue its way through the heavens without losing one of them, in spite of the fact that Galileo's opponents pronounced such behavior as "unscriptural." Finally, the sun, in which if anywhere immutability was to be expected, was scarred by dark spots and rotated about an axis!

Even in the face of such overwhelming evidence that the universe was not in conformity with the teachings of Aristotle, the vast majority of scholars still refused to accept the implications. In 1622 Francis Bacon wrote: "Copernicus' scheme is inconvenient; it overloads the earth with a triple motion; it creates a difficulty by separating the sun from the number of the planets with which it has much in common; and the introduction of so much immobility into Nature . . . and making the moon revolve around the earth in an epicycle and some other assumptions of his are the speculations of one who cares not what fictions he introduces into Nature, provided his calculations answer."

Galileo's experiments in mechanics opened a new field for exploration as far-reaching in its potentialities as the sidereal world he had discovered. He established the principle of inertia, later to be restated by Descartes in his laws of nature and embodied by Newton in the first law of motion. Galileo applied it to the moving earth to explain why birds flying through the air, and the atmosphere itself, are not left behind by the planet's motion. Yet, inconsistent as it may now appear, he explained tides as the effect of the earth's rotation, scornfully rejecting Kepler's suggestion that the ocean responded to an influence emanating from the moon.

Descartes taught men to reason and to doubt. Voltaire said of him that he was "born to discover the errors of antiquity and at the same time substitute his own." Apart from his invaluable contributions to mathematics, he advanced indirectly the evolution of the Copernican theory by pointing out that it was possible for the earth to describe an orbit about the sun without actually



René Descartes, after a painting in the Louvre, by Frans Hals.

stirring, if it were swept along by a great current as a motionless ship is borne upon the tide. Thus he reconciled the concept of a moving earth with the Scriptures and by his "vortices" prepared men's minds to accept the law of gravitation. He treated his own system, as he did those of Copernicus and Tycho Brahe, merely as a working hypothesis which "saved the phenomena." His theory was not stated with such exactitude that it could be subjected to experimental tests, yet it was held by many scholars on the Continent until the early part of the 18th century.

Descartes attributed "conductivity" to interplanetary space which he regarded as filled with a "subtle matter," suggestive of the more modern "ether." His proposition that "God . . . always preserves an equal amount of movement in the universe," sounds very much like the modern principle of the conservation of momentum. Other propositions which indicate the extent of his thinking along purely astronomical lines are: that the earth viewed from the heavens would not appear otherwise than as a planet smaller than Jupiter or Saturn; that the sun and fixed stars shine by their own light; that the moon and the planets derive light from the sun; that the moon when it is new is illuminated by the earth; that the hypothesis of Ptolemy does not satisfactorily explain the phenomena; that the hypotheses of Copernicus and Tycho do not differ if they are regarded simply as hypotheses; that the heavens are fluid; that the earth rests in its own heaven, but is nevertheless carried along by it; and many others.

During the 17th century astronomy progressed along a variety of lines. In 1655, Christian Huygens discovered the first satellite of Saturn and announced that, since the quantity of planets and satellites in the solar system had attained the perfect number *twelve,* no others remained to be discovered. Later he established the nature of Saturn's rings and must have seen other satellites without recognizing their character. He invented the pendulum clock in 1656, thus making possible more accurate measures of time, so essential a part of astronomical observations. The micrometer for precise estimates of very small angles in the sky was developed by several observers. French scientists focused attention on the determination of the length of a degree of the earth's meridian in various latitudes and discovered the flattening of the earth at the poles. Hevelius charted the features of the moon.

In the Observatory of Paris, the anti-Copernican Cassini measured the rotations of Jupiter and Mars and discovered new satellites of Saturn; and Roemer established the finite velocity of light from a study of the times of eclipses of Jupiter's moons. These same "Galilean planets" led Borelli to announce in 1666 that the heavenly bodies moved as if acted upon by a central force at right angles to the direction of motion, which prevented them from flying off along the tangent.

In 1677, Edmund Halley observed a transit of Mercury across the disk of the sun and suggested that such a phenomenon could be utilized for determining the distance of the sun from the earth—a proposal which was carried out the following century during a transit of Venus. From a comparison of ancient and modern observations, Halley identified returns of the comet which bears his name, and discovered the secular acceleration in the moon's mean motion and the proper motions of Sirius, Procyon, and Arcturus. From the behavior of Jupiter and Saturn, he suspected the existence of a trans-Saturnian planet, which was verified by the discovery of Uranus 100 years later by William Herschel.

These and many other important discoveries marked the passage of the years. The greatest individual contribution to theory, however, was the work of Isaac Newton. His law of universal gravitation and three laws of motion became the foundation for the celestial mechanics of the 18th and 19th centuries. He introduced the entirely new concept of *mass* as the "quantity of matter," and derived the masses of the sun and of those planets which possess satellites by measuring their attractions against that of the earth for the moon. He showed that the oblate figure of the earth resulted from the mutual gravitation of all its parts, combined with the centrifugal acceleration of its rotation. He predicted a similar oblateness for Jupiter which was later confirmed by Cassini's observations.

The effect of precession of the equinoxes on star places had been recognized

since the time of Hipparchus, and an accurate value had been derived by Copernicus, who also explained the mechanics of the phenomenon. But it remained for Newton to prove that precession followed as the inevitable consequence of the earth's oblateness and rotation, under the attractions of the sun and moon. It has been said of Newton that he explained the "why" of things; but even he regarded the mutual attraction of two bodies, distant from each other in space, as merely a convenient hypothesis for describing an inexplicable phenomenon.

The history of the evolution of the Copernican theory does not end with the triumphs of the 18th century; nor can an adequate account of its far-reaching consequences be presented without sketching the entire history of astronomy to the present day. With each new proof of the validity of the theory, new and grander fields for exploration have been revealed. Its growth has been by a geometrical progression. Only enough has been presented in this small compass to indicate the trend of inquiry, the gradual unfoldment of new concepts. In each of the four centuries since the birth of the Copernican system, there have been pioneers who caught the gleam of something beyond the ever-widening horizon, waiting to be discovered and explained. And so the situation still remains in the 20th century.

ABSTRACTS FROM "THE COPERNICAN THEORY"

(*Continued from page 5*)

Why was a personal visit necessary? The answer is that Copernicus was unwilling to release his book for publication. He communicated his ideas to his personal friends without hesitation, and through this channel they spread. The truth is that he was obsessed by a fear. What reception would be given to a book that subverted concepts established since remote antiquity? What would happen to the author of a treatise that seemed to many persons to contradict the Bible? It was prudent to keep one's peace.

Then in 1539 the eager young professor arrived on the scene. Rheticus was at once enormously impressed by the genius of his host, and realized that failure to publish, or even delay in doing so, meant a serious loss to science. He would take upon himself the responsibility of announcing the new system. If the book raised a storm of hostile criticism, he was prepared to bear the brunt of it. But if, on the contrary, a friendly reception awaited the pronouncement, then the fears of his revered master would be allayed, and his consent could be obtained for immediate publication of his epoch-making treatise.

In pursuance of his plan Rheticus set himself the task of composing a palatable presentation of his master's system. But he employed an entirely different style of writing. He made plentiful use of the attractive artifices of rhetoric. The scientific material was presented, but it was not packed quite so hard. Even the diagrams were omitted by Rheticus, so that his tract did not look like an astronomical treatise.

His book, entitled **First Account of the Revolutions of Nicholas Copernicus,** was so favorably received that a second edition was run off in the following year, 1541. In all probability its success, more than any other single factor, removed Copernicus' fear of adverse criticism and controversy, so that he finally agreed to put his manuscript into the hands of a printer.

Rheticus arranged to have the printing done at Nuremberg, many hundreds of miles from Copernicus' home. Rheticus was, however, unable to see it through because he had accepted a teaching post elsewhere. To carry on the supervision of the printing, he selected a prominent clergyman, Andrew Osiander, who had shown a lively interest in the mathematical sciences.

When the great treatise came off the press, its very first section was a brief Address to the Reader. This declared that no doubt some learned men had been offended by the assertion of the earth's motion; but, after all, astronomical hypotheses need not be true nor even probable.

The result was that readers did not know how to interpret the author's position. The body of the work flatly affirmed the motion of the earth as a physical fact; yet the introductory Address to the Reader said that hypotheses need not be true nor even probable.

More than 60 years passed before the confusion was cleared up. This was done by Kepler, who declared that the author of the Address to the Reader was not Copernicus at all, but Osiander. The final piece of evidence was provided by the edition of Kepler's complete works, the first volume of which appeared in 1858. This contained an essay which had never been printed before, because it was left unfinished by Kepler. It quoted correspondence that passed between Copernicus and Osiander, which made it absolutely certain that Osiander wrote the Address and that Copernicus disagreed basically with Osiander.

Shortly before the publication of this correspondence, the original manuscript of the **Revolutions** in Copernicus' own handwriting came to light. It now became clear for the first time that Osiander had suppressed Copernicus' dignified Introduction to Book I on the value of studying astronomy, and had replaced it by the Address to the Reader, which he himself wrote but from which he withheld his signature.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *May,* THE BIG DIPPER.

The Big Dipper is the best-known group of stars in the sky. In the Buhl Planetarium's sky show we turn our attention to the many discoveries about the Dipper which have been made in 400 years—since the days of Copernicus, whose quadricentennial we celebrate this month. Our start is with the great astronomer himself—we glimpse what sort of man he was and how his ideas changed this world of ours. He would have liked to know what we know about the Dipper today—that its stars are slowly shifting their apparent positions, so that thousands of years hence they will no longer form a dipper. And five of the seven suns in the Dipper are part of a huge cluster of stars through which our sun and earth are moving. Here, surely, is a story which would have amazed even Copernicus, 400 years ago!

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BEGINNER'S PAGE

VARIABLE STARS—III

BY PERCY W. WITHERELL

AT the beginning of the present century, man was rather pleased with his knowledge of the extent of his galaxy. When its dimensions were compared with the universe's supposed extent 100 years previously, there really was ground for such complacency. There did not seem to be much chance of greatly extending the early 20th-century boundaries, until some brilliant minds noticed the Cepheids, and used the peculiar relation of their magnitudes to their periods to expand our knowledge of the size of the universe to an almost unbelievable extent.

The light curve of a variable star is the plot of observations of its apparent magnitude against the time of the observations. Last month we showed such a curve for an eclipsing binary, in which deep and shallow minima alternated as the stars alternately eclipsed each other. The typical light curve of a Cepheid variable is of quite a different appearance, as the accompanying example shows. From minimum light, the increase in brightness is comparatively rapid, while the fall from maximum is more gradual and somewhat irregular. The minimum is usually of longer duration than the maximum. *Cluster-type* Cepheids are those of extremely short periods—they go through their cycle of phases in less than a day, and in some instances, the light doubles in less than an hour. Zeta Geminorum is representative of a few Cepheids whose rise and fall are of about equal speed.

The visual range of Cepheid luminosities is usually less than one and a half magnitudes, and the variation of those of very short period is often only a few tenths of a magnitude. Usually, Cepheids are redder at minimum than at maximum, changing their spectral class simultaneously with their changes in brightness.

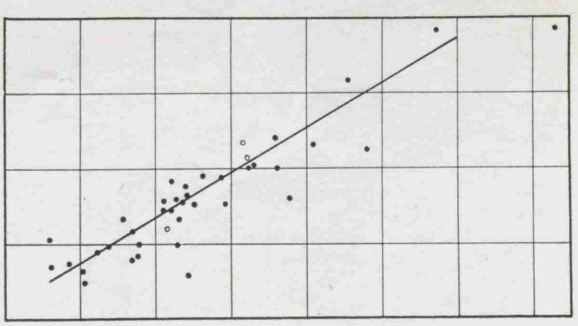
The stars of periods averaging half a day are of spectral class *A*. Cepheids of 4-day periods are about *F*5; those of 8 days, *G*0; and those of over 20 days are about *G*5, but the fluctuation around these means is considerable. The change in spectral class during the variation of its light shows that the star's surface is undergoing changes in temperature (and pressure) which are believed to be the result of alternate contraction and expansion of the star. Confirming this are the periodic Doppler shifts of Cepheid spectra: maximum velocity of approach of the star's surface (violet shift) occurs at or near the time of maximum brightness, while a corresponding maximum velocity of recession (red shift) is observed near the time of minimum light. We shall reserve discussion of the physical explanation of this pulsation of the Cepheids and of other intrinsic variables until we have described the long-period variables in a future article.

At present we are more interested in the relation between the period of a Cepheid and its total luminosity. The real brightnesses of these useful stars show a progressive increase, first discovered in 1912, when Henrietta Leavitt noted a relationship between the apparent magnitudes and the periods of 25 variables in the Small Magellanic Cloud.

These stars all had light curves similar in form to that of the well-known variable, Delta Cephei. Miss Leavitt wrote: "Since the variables [in the Cloud] are probably at nearly the same distance from the earth, their periods are apparently associated with their actual emission of light, as determined by their mass, density, and surface brightness." In other words, the Cloud was assumed to be so distant that all of its stars could be assumed to be about the same distance from us; consequently, the *relative apparent* magnitudes could be considered as giving the *relative absolute* magnitudes. However, since the actual distance of the Cloud was then unknown, the numerical values of the absolute magnitudes could not be determined. The importance of Miss Leavitt's discovery was that she showed Cepheids to have a peculiar characteristic—those of longer period had greater intrinsic luminosities than those of short period.

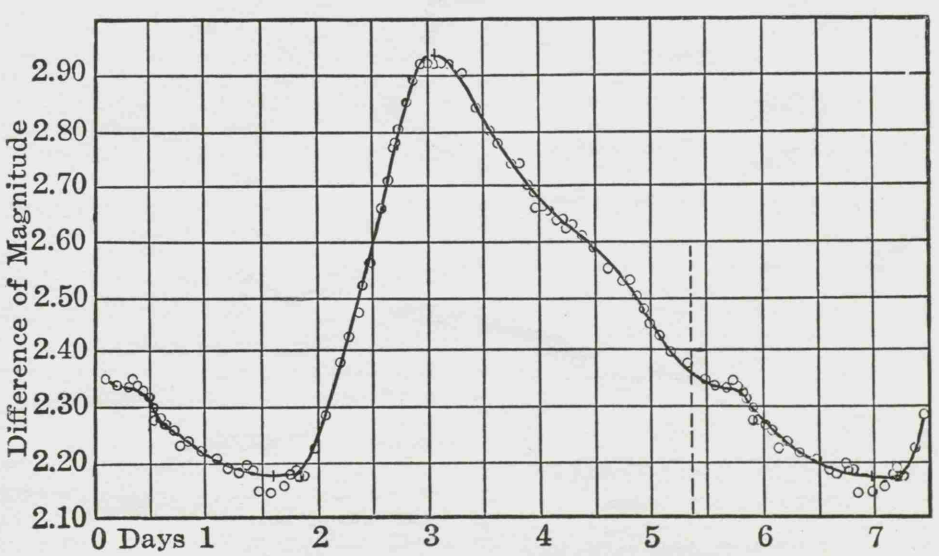
Then, Dr. Harlow Shapley made a series of studies of Cepheids, including those in globular clusters, and in 1918 published the visual *period-luminosity* curve; 11 points on this curve were fixed by our knowledge (by other methods) of the absolute magnitudes of 11 comparatively nearby Cepheids. Later this curve was improved by photographic observations and the adoption of 0.00 as the absolute magnitude of the cluster-type Cepheids.

As a consequence of this remarkable correlation, a Cepheid, wherever it may be in the universe, telegraphs us the clue to its real brightness by the period of its light fluctuations. If a Cepheid is identified as such in some distant cluster or galaxy, and its period can be determined, this period-luminosity relation gives its absolute magnitude. Knowing its absolute magnitude and observing its apparent magnitude, the star's distance can be easily computed. By this means, the distance of the nebula in Andromeda has been set at about 700,000 light-years, and the distances of thousands of other galaxies and clusters have been obtained. The greatest extent of our own galaxy is found to be more than 100,000 light-years, and the Magellanic Clouds are nearly that far away. The uniformity of Cepheid behavior everywhere in the universe seems to be amply confirmed.



(Right) The period-luminosity relation for 40 Cepheids in the Large Magellanic Cloud. Ordinates are median apparent photographic magnitudes from 13 (top) to 17 (bottom). Abscissae are logs of the period in days from 0.25 (left) to 2.0 (close right).

(Below) The light curve of Delta Cephei, by Joel Stebbins, Washburn Observatory.



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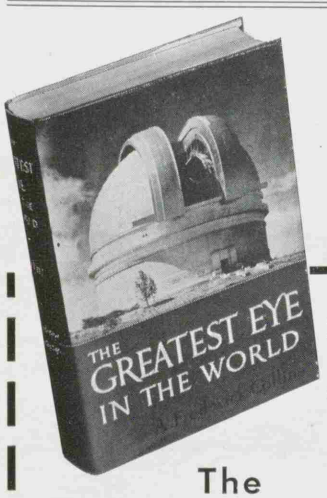

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BOOKS AND THE SKY

ATOMS, STARS AND NEBULAE

Leo Goldberg and Lawrence H. Aller. The Blakiston Company, Philadelphia, 1943. 323 pages. $2.50.

THAT a book can at the same time serve as a textbook in modern astrophysics and as a general book for the interested reader who wants to know the methods and results of modern astronomical spectroscopy may be difficult to believe. But the authors of this elegant volume (the fifth in the Harvard Books on Astronomy) have succeeded in making it fulfill such a dual purpose; like its predecessors in the series, it should have a wide sale and use.

The narrative style is well maintained throughout the book. The technical details are largely summarized in tables liberally sprinkled through the pages; these contain data concerning temperatures, masses, densities, and other characteristics of the stars. The numerous diagrams and graphs aid in visualizing the processes and results expressed in the text, and the many fine halftone reproductions of typical and peculiar spectra make the book useful as a reference work. As in the other Harvard books, photographs of contemporary astronomers add a worthwhile touch.

There is a very definite need for such a book in college courses. In many colleges where interests are not highly technical, outdated textbooks in astrophysics are in use. In others, the instructor's own notes are used, and they are likely to be somewhat heavily weighted in favor of the particular techniques and investigations current at that institution. This book, supplemented with reading from the current literature, would be ideal for use in an introductory course in astrophysics.

As for the general reader, he will find here the answers to his "How do you know?" questions, in form palatable to him, if he really wants to know. Most scientists will agree that the English language is never more precisely used than in science, and he who would read any "popular" science book profitably must read every word, for each one has a definite part to play in the whole story. If this book is read with that thought in mind, it will provide many hours of thorough enjoyment to the serious amateur. It is a very worthy companion to its fellows in the series.

ROY K. MARSHALL
Fels Planetarium

BASIC PRINCIPLES OF WEATHER FORECASTING

Victor P. Starr. Harper and Brothers, New York, 1942. 299 pages. $3.00.

THIS volume with many diagrams and full-page maps is not an elementary book. The reader must be familiar with the modern tools of forecasting before it can be understood; however, the mathematics is kept at a minimum, with the practical aspects emphasized. Outlines for forecasting principles as applied to the 10,000-foot pressure chart and the sea-level pressure distribution are given. The outline includes the semi-permanent pressure formations and intensity of the general circulation, the characteristic features of low and high index type circulations in summer and in winter, and perturbations of the westerlies in middle latitudes. Following this outline, a chapter is devoted to forecasting the actual weather from the field of motion. A short chapter describes the type and size charts and graphs and wind scales used in forecasting.

Separate chapters give examples of forecasting during the four seasons; they include full-page prognostic charts and the actual maps of both sea level and 10,000-foot levels. Another chapter deals with forecasting from local indications of pilot balloon and radiosonde as well as surface observations. Many of the practices recently developed at the University of Chicago are given. The last chapter deals with five-day forecasts. Thirty pages tell of the techniques, data, actual and prognostic charts of the weather; an example and procedure are shown.

An appendix, written by C. G. Rossby, D. Fultz, H. G. Dorsey, and M. Boyden, deals with the forecasting of flow patterns in the free air by the trajectory method; the theory and an example are given.

On the whole, the book is the first of its kind; it deals with the principles from a practical standpoint and follows them up with real examples.

J. H. CONOVER
Blue Hill Meteorological Observatory

A START IN METEOROLOGY

Armand N. Spitz. Norman W. Henley Publishing Company, New York, 1942. 92 pages. $1.50.

AIR NAVIGATION FOR BEGINNERS

Scott G. Lamb. Norman W. Henley Publishing Company, New York, 1942. 103 pages. $1.50.

THE little book by Armand N. Spitz, president of the Rittenhouse Astronomical Society, is a most readable beginner's meteorology text. It is written so that it may be read with pleasure and profit by any 12- to 15-year-old boy or girl interested in learning about the weather. There is, however, no reason why it should not prove equally acceptable to older people. Because of the temporary suspension in the issuing of detailed weather forecasts, many of us have become more weather-conscious than we were in the past. The Spitz book could well become the average citizen's guide for weather forecasting during the emergency. It shows how, with the aid of a simple barometer and thermometer, everyone may start on a career as a weather forecaster.

One may always quibble with an author of a beginner's text about balance and the choice of topics. This reviewer frankly finds little to criticize in this enjoyable and well-written volume. I have two criticisms, but they are not aimed at

the text. The first is that, much as I admire the skill of the author as draftsman, I do not think that the rough drawings scattered in large numbers through the book are suitable. Some of them are very well done (notably the large figures on heights of the clouds and the source regions of air masses), but others are so carelessly drawn as to be annoying to any eager reader. I cannot understand why the author and publishers did not substitute a few good cloud photographs for the smeary cloud drawings that appear now in the book. Secondly, I object to the price, which is about double that for other books of similar size and character.

I cannot become over-excited about the book on air navigation. It bears all the earmarks of having been written by a marine navigator who became interested in air navigation as a side line. The chapter on the compass and its corrections is unnecessarily complex. Piloting and bearings are treated far too much from the point of view of the marine navigator. The treatment of wind problems is confusing. The two brief chapters on celestial navigation are inadequate to the extreme. There is certainly no excuse for introducing the beginner to sidereal time in these days of hour angles! The drawings are neat but uninspired. We need a book on air navigation for beginners that does just what the Spitz book does for meteorology; to this reviewer it seems that the Lamb volume does not do the job.

BART J. BOK
Harvard College Observatory

JULES VERNE—The Biography of an Imagination

George Waltz, Jr. Henry Holt and Company, Inc., New York, 1943. 223 pages. $2.50.

ANY person anticipating a historically accurate biography of Jules Verne will undoubtedly be disappointed in this book. The meager facts available have been supplemented by fiction—as frankly stated by the author—and the feelings of the characters have often been supplied in a manner more suited to autobiography and the romantic novel than to staid history. Anyone expecting a scientific evaluation of Verne's plots is also doomed to disappointment, for here is only a partially critical investigation.

But what of that? Jules Verne was not a scientist; he did not have to be. He was a writer endowed with an imagination, with which he thrilled his readers, describing, among other things, a trip to the center of the earth. Does it matter, seriously, if such a trip is impossible? And is the stimulation to the reader's imagination any less valuable if his ultimate reasoned conviction is that such a trip is impossible? Jules Verne was a popularizer of geography and science: his excellence is as a popularizer, and we are pleased to accept him as such.

Mr. Waltz is not unlike Jules Verne: his book is no more a critique or a biography than Verne's books were geographies or scientific treatises; but like Verne he has written a fictional account which will popularize his basic subject. Myriads love Verne for what he is, asking no more. Myriads of Verne-lovers will enjoy placing Mr. Waltz's imaginative biography on their shelves along with Verne's imaginative science.

LAURENCE J. LAFLEUR
Barnard College

MAN'S PHYSICAL UNIVERSE

Arthur Talbot Bawden. The Macmillan Company, New York, 1943 (Revised Edition). 832 pages. $4.00.

"ONE of the fundamental purposes of **Man's Physical Universe,**" states the author, who is president of Stockton Junior College, "is to enable students to obtain a sufficient background in the field of the physical sciences to enable them to keep up with the developments of science and technology."

In this aim he should succeed admirably, for the book covers in concise units such fields as astronomy, geology, meteorology, electricity, nuclear physics, plant physiology, organic chemistry, and chemotherapy, and all with a minimum of technical terminology.

But it is more than a miscellaneous collection of information. I believe that it was Poincaré who said that a collection of facts is no more a science than a pile of bricks is a house. President Bawden, in his preface, expresses a similar thought:

"A great neurologist showed me how he did his work. In the study of the brain he first prepared very thin slices which he could study in minute detail under the microscope. After making these studies his next great task was to trace the relationships from one slice to another, and not until he did this could he arrive at any meaning in his work.

"Science has done a beautiful job in preparing individual slices of knowledge; but until these slices are fitted together to form a whole again, they will have little meaning. It is the purpose of the survey course [for which this is a text] to try to fit these slices together and to discover a pattern running through all of the sciences that will provide not only intelligible but useful knowledge.

"It has been one of my great concerns," he continues, "that the student be led to develop open, critical and cultural attitudes of mind that will lead him to attempt to use the scientific method in the important problems of life."

To meet this aim, the social implications of the various topics are emphasized. Indeed, the first 50 pages are devoted to the intelligent solution of problems, and the reader is urged to think for himself. Among the suggested topics for discussion are "Should you treat your teacher as an authority?" and "Why is the atmosphere of the lecture platform not favorable to intellectual honesty?"

Since so many of the world's troubles can be traced to unscientific thinking, the importance of this approach is obvious. It is just as vital to the general reader as to the student. While this book is written as a text, it should be of interest and value to a wide group outside of colleges, since it not only summarizes the remarkable achievements of science but indicates as well their broader significance.

JAMES STOKLEY
General Electric Company

THE LITTLE PRINCE

Antoine de Saint-Exupéry. Reynal & Hitchcock, New York, 1943. 91 pages. $2.00.

THIS is a story with as much meaning for adults as for children, and with enough astronomical references, serious, naive, and otherwise, to entrance the star lover. Its unique humor is always pleasant, and its lovely colored drawings give it a singular character. Asteroid B-612, the home of the little prince, boasts three volcanoes. "Two volcanoes are active and the other is extinct. But one never knows." The little prince also had one flower on his planet, which he placed under a glass globe when he started on his journey. The seventh planet he visits is the earth.

C. A. F.

NEW BOOKS RECEIVED

AIRCRAFT MATHEMATICS, *S. A. Walling and J. C. Hill*, 1943, *Macmillan*. 189 pages. $1.25.

Arithmetic, algebra, geometry, trigonometry, in a textbook with the emphasis on these subjects as used in aviation. Of special interest are chapters on Ratio, Relative Velocity, Three Systems of Measuring Angles. Numerous examples and problems make it excellent for the self-taught.

SCIENCE FROM SHIPBOARD, 1943, *Science Service, Washington*. 268 pages. 25c.

A simple and extremely informative manual by various authors covering meteorology, navigation, astronomy, sea and bird life, and other subjects of interest to traveler on transport or pleasure cruise.

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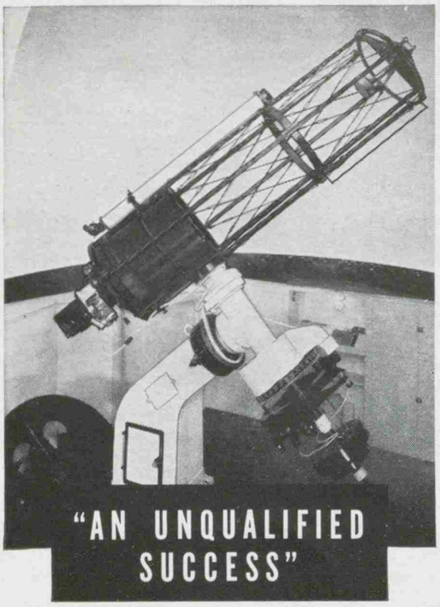

From Volume VIII, No. 6, Publications of The Observatory of The University of Michigan describing the Francis C. McMath Memorial 24-inch Reflecting Telescope, now in operation at the McMath-Hulbert Observatory of the University of Michigan.

"The mirrors were entrusted to The Perkin-Elmer Corporation. Our specifications were exacting, as no part of any surface could depart from the theoretical surface by more than one-tenth of a standard wavelength . . . Perkin-Elmer Corporation completed the primary mirror by conventional methods...It was then tested, pronounced well within the specifications, and found to have an unusually fine surface. The two high magnification secondaries, however, presented real difficulties. McCarthy, of Perkin-Elmer, felt that conventional methods of testing were inadequate and proposed a new method, which he has recently described. The Perkin-Elmer Corporation made up the necessary auxiliary optical equipment, and our two secondaries were figured by the new method, which eliminates the combined testing of primary and secondary. These two mirrors have been an unqualified success, both focal lengths being well within specifications, while the figuring is superb. Exposures for the disk of Jupiter are shorter by a factor of at least twelve when compared with our old 10½-inch telescope."

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GLEANINGS FOR A. T. M.s

Making a Schmidt Correcting Plate

WHY are not more Schmidt cameras constructed by A.T.M.s at the present time? As one who has constructed a number of cameras, from f/0.5 up, I can say that a Schmidt gives more satisfaction to an A.T.M. than any other instrument within his power to make. To raise the objection that the grinding of a Schmidt correcting plate is work for advanced amateurs is "pure bosh"—it is simpler to make than any true surface mirror.

At the present time, of course, one is faced with the material shortage situation with respect to carborundum, but there are several alternative methods for roughing out the primary mirror. One is by sand-blasting (see **The Sky,** October, 1941); another is by turning on a lathe with a carboloy tool bit and a radius rod. However, this article is not concerned with the construction of the primary mirror—that problem is well covered in many sources. I shall confine myself to the preparation of the correcting plate.

1. **Material.** The plate is made of plate glass—about ¼" thick; Vitaglass is best, if it can be procured, because of its high transmission properties in the ultraviolet region—but Crystallex is also very good. If Vitaglass is used, it is wise to examine the piece for striae, which are rare but not always absent. If the sheet is held in front of a completed mirror of any size, any striae present are easily observed by their deflection of light.

The plate should be made as large as the primary mirror, even though the final aperture will be much smaller—the larger size facilitates working, and avoids trouble at the edge.

2. **Preliminary Work.** Before starting the bell-shaped curve on the correcting plate, it should be accurately plane-parallel (0.00025"). Sometimes it is possible to do this by polishing on an HCF full-size lap—if so, press the HCF with a ground flat—but it is usually better to go to fine emery. Measurements should be made with a 10-thousandths micrometer. One side is then polished flat, and we are ready to start the curve on the reverse side.

3. **Grinding the Curve.** The shape of the curve to be ground is determined by the usual equations, obtainable from several sources (see **The Sky,** July and September, 1940), when one has already obtained the other data for the instrument.

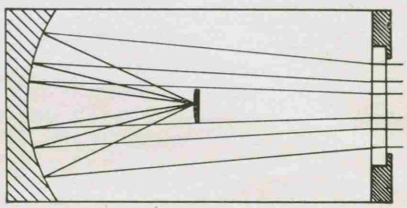
The grinding should be done with a lap made up of ½-inch square, flat unglazed bathroom-floor tiles, mounted on sponge rubber or thick plain rubber backing in the form of a ring. The tiles can be mounted with pitch, which should be boiling. The mean diameter of the ring of tiles should be equal to 7/10 of the diameter of the correcting-plate aperture in the instrument. For instance, if the instrument has an 8-inch mirror of 6-inch focal length, working at f/1.5, this would call for a correcting-plate aperture of four inches; whence 7/10 of 4 is 2.8 inches. It is better to make the ring a little large, so three inches would be the proper mean diameter for the annulus. The width of the annulus should not be greater than a fourth of its mean diameter.

Fine emery (about 303½ or equivalent) is used for the grinding, which is done with the aid of a rubber sink plunger rotated between the hands. About one hour of grinding is required before the first testing.

Incidentally, the used emery can be reclaimed if it is put into a high, narrow tube, filled with water, and allowed to settle. Abrasive is then taken off the top, never using that which sinks to the lower half of the tube.

4. **Testing.** The best method of testing is as follows. This procedure is used for testing both during the grinding and polishing stages:

Construct a small box, containing a small electric lamp, with a frosted glass window for one side. The window is covered with a fine wire screen (the finer the better) and mounted at the focus of the primary mirror, facing the



The paths of light rays which enter a Schmidt camera parallel to its axis.

mirror. The correcting plate is then mounted at the center of curvature. These distances are important, and should be measured very carefully.

The correcting plate is observed from a distance, looking through the plate. The pattern of the screen is easily observed, and any distortion is noted. If the plate is perfectly corrected, there will be no distortion, even at the edges of the plate.

During the grinding stages, the plate is wet with a mixture of kerosene and a light oil, which will render it transparent and it will not dry off too quickly to permit testing. At this time, the observing distance can be from five to 25 feet.

During the polishing stages, get as far away from the camera as possible (up to 150 feet) when testing, and during the final stages, observe the pattern with a small 10x telescope. When no distortion is evident at a distance of 150 feet, the plate will give extremely satisfactory results.

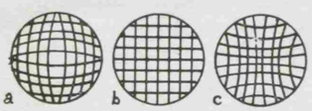
5. **Polishing.** A rotating spindle is necessary for polishing. This can usually be rigged up very simply, as it need not be elaborate. The polishing lap is made up of small disks of pitch on sponge rubber or rubberized cotton belting. The latter is best, as it gives a somewhat firmer backing for the pitch. The disks are made by dropping melted pitch on the backing, taking care that the disks do not overlap or run together. It is also possible to polish with an HCF lap, mounted on sponge rubber, with ⅜-inch

squares ⅛ inch apart. The HCF should be mounted on cork, which in turn is mounted on the sponge rubber. The lap should be circular and about half the size of the correcting plate for zonal finishing, but full size for the first polishing.

6. **Zones.** One of the principal difficulties encountered will be with unsymmetrical zones, and the interpretation of the distortion seen on the test. The following will be helpful:

Barrel-shaped distortion:
- If occurring in the central part of the plate (out to the 7/10 zone), indicates a high zone.
- If occurring near the edge, indicates a low zone.

Pin-cushion distortion:
- If occurring in the central part, indicates a low zone.
- If occurring near the edge, indicates a high zone.



Types of distortion: (a) barrel-shaped or overcorrected; (b) correct; (c) pin-cushion or undercorrected.

7. **Caution.** Be sure not to permit the center of the plate to receive much grinding or polishing. Of course, it must be completely polished, but if a low zone is induced near the center, it means taking down all the rest of the plate to the corresponding level.

ARTHUR DeVANY
2850 27th St., N. W.
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Sauce for the Gander

READERS are asked to send in questions, from which this editor will select the best each month to answer here. The last question is left unanswered, but the reader should be able to find the answer for himself. This month's question came from F. Czyzewski, of South Bend, Ind., and from many others.

Q. What causes sunrises to continue to occur late for nearly two weeks after the winter solstice, December 22nd, while all the increase in the length of the day seems to occur in the afternoon, making the sunsets get later rapidly? And why does the opposite effect hold true after June 22nd, with sunsets continuing to be late until after July 4th?

A. This apparent anomaly results from the two independently variable conditions which affect the time of sunrise and sunset. The better known of these is the variation of day and night lengths resulting from the inclination of the earth's axis. The earth's axis is inclined toward the sun in the summer, away in the winter—the hours of daylight increase from the winter solstice to the summer solstice, but decrease during the other part of the year. If this were the only factor, the time of sunset would advance equally as the time of sunrise receded during the summer and fall, and vice versa during winter and spring. It is this sequence of events which most people take for granted, until they happen to examine a table of sunrise and sunset in an almanac.

The second factor is that of the so-called **equation of time,** which is itself the result of two phenomena—the inclination and the eccentricity of the earth's orbit. This equation of time is familiar to navigators as the difference in the time shown by a watch (mean time) and the time shown by a simple sundial (apparent time), in both cases considering the local time for the place. Readers are referred to standard astronomy and navigation texts for detailed explanations necessary to understanding how the eccentricity and inclination combine to make the equation of time a variable quantity. In other words, the sun does not move uniformly eastward among the stars, and so makes a poor clock. Therefore, the apparent solar day (time from one passage of the sun across the meridian to the next passage) is longest late in December, shortest in March and September, and reaches a secondary peak in June. This moves noon by the clock backward during November, December, and January; the sun reaches the meridian in the forenoon in late September, but is a bit later every day thereafter until it coincides with the clock about December 25th, after which it is late in getting to the meridian for another month and a half. (During this period the equation of time has been changing from its maximum positive to its maximum negative value.)

Consider now the joint effect of both factors. After December 24th, both morning and afternoon are gaining time because the sun is moving northward and the day is getting longer. But because of the change in the equation of time, the afternoon is gaining time at the expense of the morning, and for some days the latter effect is greater than the former. Hence, the sun continues to rise later in the morning, although it sets so much later in the afternoon that the length of the morning and afternoon combined increases.

A similar explanation can be applied to the situation at the time of the summer solstice.

Q. What are the Widmanstätten lines in a meteorite?

L. J. LAFLEUR

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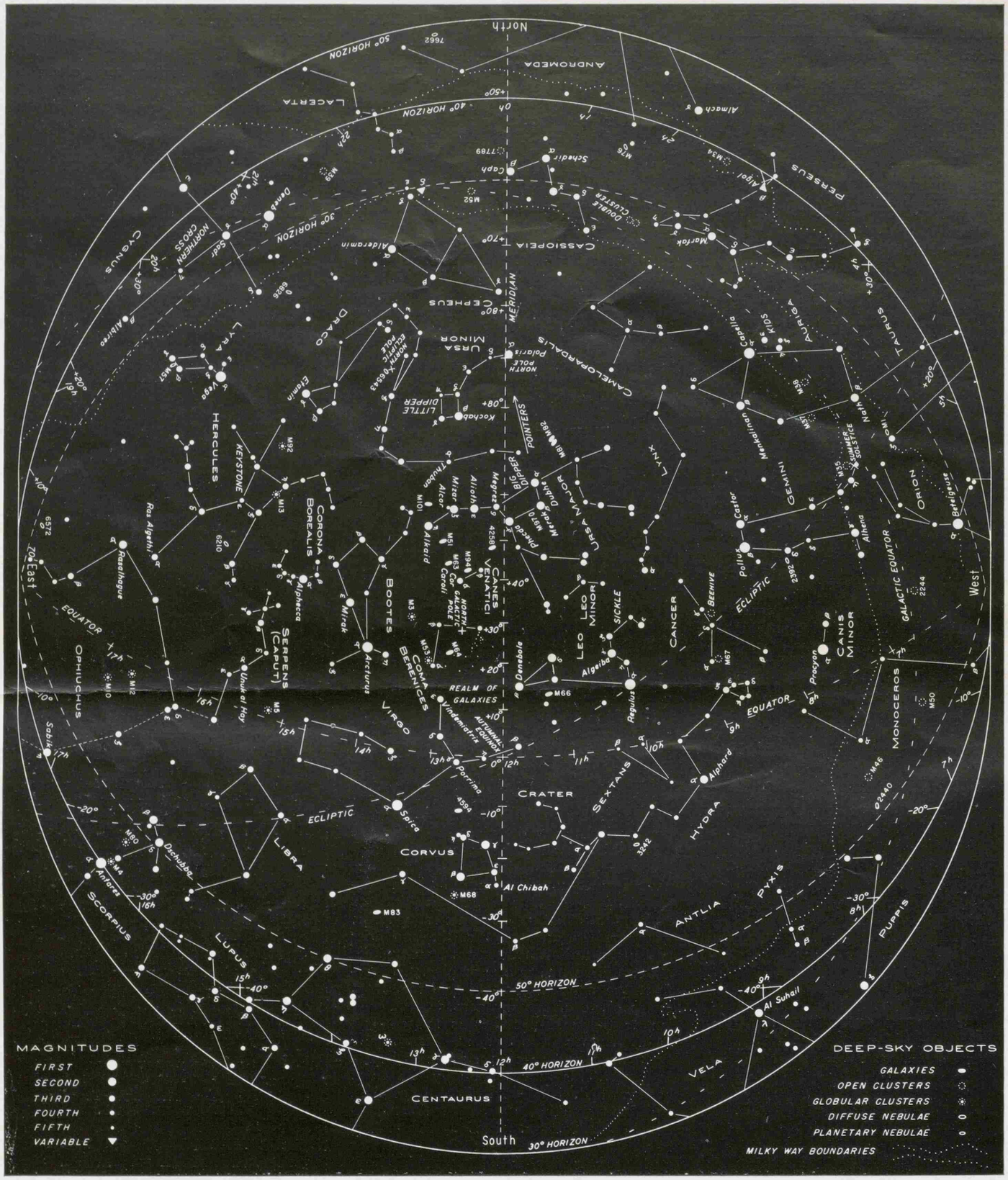


DEEP-SKY WONDERS

THIS month finds the following objects in good position for observation with moderate-sized telescopes. Descriptions are from Norton's **Star Atlas.**

Centaurus. Omega, a beautiful globular cluster, easily visible to the naked eye, "like a tailless comet, nearly 4th magnitude." It is 30′ in diameter, and contains thousands of 12th- and 15th-magnitude stars. Its position is $13^h\ 23.7^m$, $-47°\ 3'$.

Ursa Major. M97, $11^h\ 11.8^m$, $+55°\ 17'$; the Owl nebula, a large faint planetary, 3′ in diameter. Large aperture, low power, and a clear night are required for a good view.

Coma Berenices. M64, $12^h\ 54.3^m$, $+\ 21°\ 57'$; the Black-eye nebula, a bright oval, with a dark central area of absorbing matter, visible in large telescopes. N.G.C. 4565, $12^h\ 33.9^m$, $+\ 26°\ 16'$; the largest edgewise spiral, 15′ x 1′, with a bright center.

THE STARS FOR MAY

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

AIR AND SEA AND SKY

A department devoted to wartime subjects related to astronomy, such as aerial and celestial navigation, and meteorology.

Navigating in the Air — II

MODERN celestial navigation is based almost entirely upon the line of position, discovered by Capt. Sumner in 1838. In this magazine the method of working up a fix using such lines was discussed by several writers recently, but it is worth our reviewing the theoretical principles involved.

We must begin by making an assumption familiar to all students of astronomy who are acquainted with the concept of the celestial sphere: that light rays coming to us from celestial bodies are parallel. Most heavenly bodies are so far distant that for practically all purposes this is true. For members of the solar system, particularly the moon, it is not true, and certain corrections must be made. These are usually applied to our sextant observations and make it possible, in considering its circle of position, to treat the moon or a planet as if it were as distant as a star.

In the accompanying diagram, the center of the earth is at O. Let S be a star or another celestial object, and P that point on the earth's surface at which the star is directly overhead. (For purposes of explanation, we may assume the zenith to lie along a line from the center of the earth through the observer's position on the surface.)

A, B, and C are the positions of various observers on the earth, and Z^1, Z^2, and Z^3, their respective zeniths. According to our assumption, the star will appear in the directions of S^1, S^2, and S^3, respectively, these directions being parallel because all the light rays coming from the star are parallel, wherever they may strike the earth.

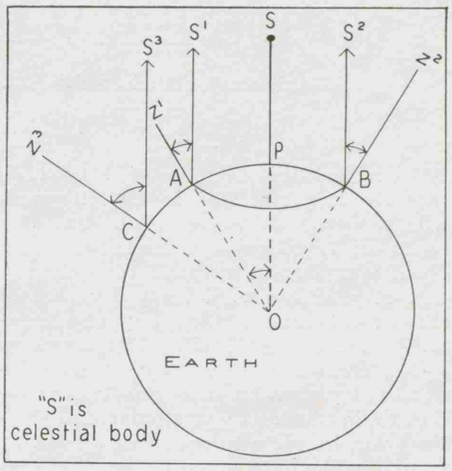
The angle Z^1AS^1 is the zenith distance of the star as seen from A, that is, the angular distance of the star from Z^1. But this angle is equal to the angle AOP, the angle at the center of the earth between P and A. In other words, the angular distance over the surface of the earth from the observer to the point where the body is overhead is equal to the zenith distance of the body. It is obvious that there must be other points on the earth where the zenith distance of S will be equal to this same quantity, such as at B.

The angle BOP is equal to AOP, so a circle with P at its center can be drawn through A and B and all the other points for which S has the same zenith distance. The radius of this circle is equal to the arc subtended at O by the observed zenith distances. But for an observer at C, which is farther from P, the zenith distance will be correspondingly greater, while for an observer who is nearer to P, the zenith distance will be less.

The zenith distance of an object is the complement of its altitude: 90 degrees minus the altitude. Since it is more practicable to observe the altitude than the zenith distance, the navigator makes such an observation to find the radius of the circle of position on which his craft lies, the center of that circle being the point where the body observed is overhead.

The position of this point on the earth, known as the substellar, subsolar, or sublunar point, as the case may be, is easily determined. Its latitude is equal to the body's declination. Its longitude is equal to the body's Greenwich hour angle. If the Greenwich time is known, these values may be easily found from an almanac. It is for this reason that we must time our sights accurately, for the rotation of the earth changes the position of the center of the circle of position constantly, and at a rate generally faster than that at which we are moving ourselves.

If we were to find the position of the substellar point on a globe, we could, using a pair of dividers, describe the circle of position. A similar observation of another body taken at the same time would yield another circle, intersecting the first at two points. Our position would be at one of these intersections. In practice, however, these circles are not actually drawn at all, nor is a globe used, except in certain methods of less practicability and accuracy. A small arc of each circle, represented by a short straight line, is plotted upon a large-scale chart. These

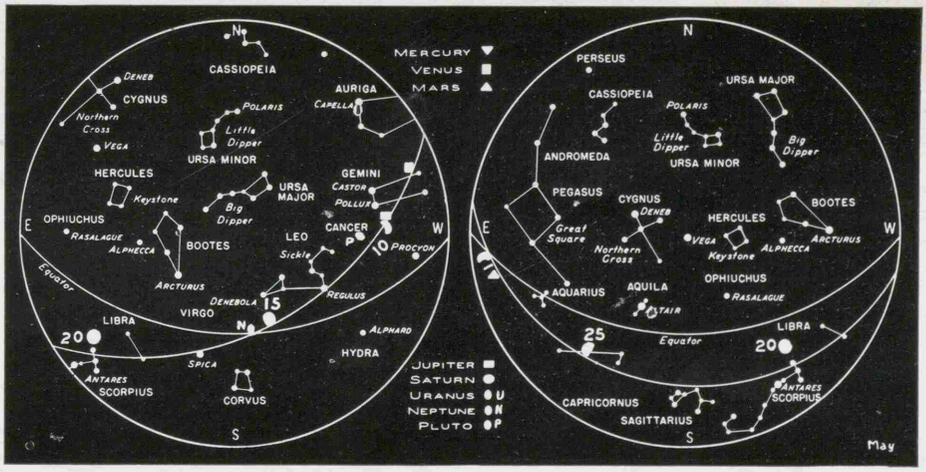


are the lines of position, and their intersection gives our fix.

It is interesting to note that if the azimuth of the body could be determined with an accuracy comparable to that with which the altitude is measured, the position of the craft could be found from one observation alone. For example, if we observe a body due south at an altitude of 40 degrees, its zenith distance would be 50 degrees, and we would be 50 degrees to the north of the substellar point. But in this case, the direction "due south" could not be observed as being definitely and exactly of that value. Therefore, we draw the line of position perpendicular to due south, but we do not know our position along that line until we have found another line intersecting it at an appreciable angle.

S. S.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 4:30 a.m. on the 7th of the month, and at 3:30 a.m. on the 23rd. At the left is the sky for 10:30 p.m. on the 7th and for 9:30 p.m. on the 23rd. The moon's position is marked for each five days by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury will be too close to the sun for observation except for the first two or three days of the month.

Venus, in Taurus and Gemini, will be 20′ north of Epsilon Geminorum, magnitude 3.2, on May 19th. The planet's magnitude will be −3.7 at the end of the month.

Mars, in Aquarius and Pisces, will arrive at the vernal equinox at the end of the month. Its magnitude of 0.8 will make it about as bright as Altair.

Jupiter will be in Gemini.

Saturn and **Uranus,** in Taurus, are too close to the sun for favorable observation.

Neptune. See chart in the March issue.

OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

Regulus in Occultation and Conjunction

By Jesse A. Fitzpatrick

DURING the evening of May 12th, the brightest star in Leo, Regulus, will be occulted by the moon. Out of a series of 17 Regulus occultations going on at present, this event is the only one that may be observed from any part of the United States. (See **Sky and Telescope,** December, 1942.) The southern states, from the Rocky Mountains eastward, may witness the occultation, although in the more western states daylight will interfere to a certain degree.

The path of the moon during that evening will be in a southeasterly direction—slightly more than 15 degrees south of due east. As the moon moves over our Pacific coast area, the occultation would be observed from Mexico to Canada were it not for daylight. Regulus, magnitude 1.3, is practically unobservable when the sun is above the horizon. We find in the **American Ephemeris** that at standard station Long. 120° W., Lat. +36°, which is midway between San Francisco and Los Angeles, the occultation will begin at 6:04.8 p.m. P. W. T., or about two hours before sunset. At that location the event will occur east of the local meridian (the negative type), and the star will emerge at 7:37.9 p.m., but still in daylight.

As the moon moves toward the east, observers in the middle of Arizona and Utah will see it intercept the light from Regulus when the star is close to the meridian. Sunlight and twilight will still interfere, but the emersion should be visible. From there to the Atlantic coast, the occultation will be of the positive type, that is, west of the local meridian.

Since the path of the moon is southeasterly, it will have moved so far south by the time it reaches the Mississippi valley that only the southern half of the central states can witness the occultation. At standard station Long. 91° W., Lat. +40°, which is near Quincy, Ill., there will be a short occultation just below the northern limb of the moon: immersion at 9:22.0 p.m. C.W.T., P. 55°; emersion at 10:03.6 p.m., P. 356°.

At Chicago, the star and the moon will be in conjunction in right ascension at 10:04 p.m. C.W.T., but there will be no occultation. The star will be about 2′ north of the moon's edge, although, as shown in the diagram, prior to the conjunction it will have passed **very close** to the northern limb.

Nineteen minutes after the Chicago conjunction, a similar event will be observed from Washington, D. C., with Regulus about twice as far from the moon. And one minute later, at 11:24 p.m. E.W.T., New York observers will see Regulus about 6′ north of the moon. The position angle of the moon's axis will be 22°, so the conjunctions will be in line with the crater Strabo.

These events all demonstrate the trend of the moon toward the southeast, and if we visualize the "shadow" of the moon "cast" by the light from the star to have a diameter of 2,160 miles, we can understand why the southern tier of states may see the occultation. To give observers in those states a very approximate idea of the times to watch the event from their respective local stations, I have computed the data for Fort Worth, Tex., and Miami, Fla., using only approximate latitudes and longitudes as scaled from an atlas map—a procedure accurate enough for this occasion and purpose.

	Ft. Worth (C.W.T.)	Miami (E.W.T.)
Immersion	9:00.9 p.m.	10:49.3 p.m.
Position Angle	93°.5	85°
Emersion	10:24.7 p.m.	11:56.0 p.m.
Position Angle	319°.5	327°.5

The star will disappear for 84 minutes at Fort Worth. Immersion at Miami will occur 35 minutes before emersion at the Texas city. From these times, a resident of a neighboring state should be able to interpolate, with a fair degree of accuracy, for the times at his location. In that vast area, there are bound to be some clear skies, and well-planned observations to time the occultation should be made. The war has reduced the number of occultation observations to an alarming extent; the Occultation Committee of the A.A.V.S.O. will welcome reports, which should be sent to Dr. Alice H. Farnsworth, Mt. Holyoke College, South Hadley, Mass.

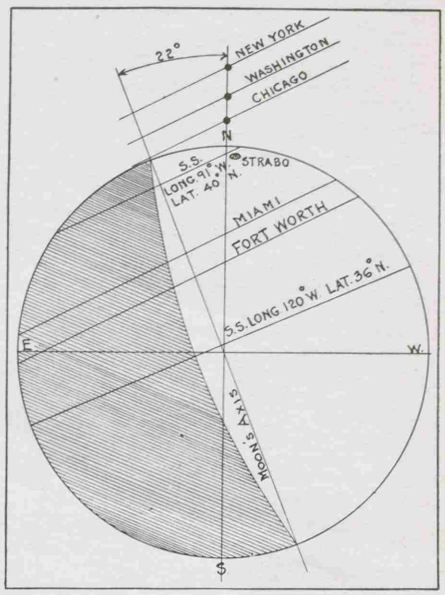
The observer's exact latitude and longitude are essential and can probably be ascertained by consulting maps at the local county clerk's office. A reading glass will help read the second-hand dial on an ordinary watch so the time may be determined to the half second. Careful checking of the watch is necessary; a time signal lasting one second is broadcast hourly on the Red, Blue, and Mutual networks; the start of the signal is the beginning of the hour.

OCCULTATIONS — MAY, 1943

Local station, lat. 40° 48′.6, long. 4h 55.8m west.

Date	Mag.	Name	Immersion	P.*	Emersion		P.*
May 7	7.1	BD + 18° 1040	10:08.7 p.m.	121°			
11	5.6	Pi Cancri	7:22.7 p.m.	140°	8:40.8 p.m.		262°
16	5.9	65 Virginis	11:26.7 p.m.	133°	0:44.1 a.m.	(17)	282°
17	5.8	66 Virginis	0:30.0 a.m.	150°	1:33.0 a.m.		261°
22	5.4	15 Sagittarii	1:42.4 a.m.	120°	2:53.5 a.m.		251°
22	6.0	16 Sagittarii	1:49.8 a.m.	41°	2:36.9 a.m.		331°
24	5.5	Sigma Capricorni	1:30.6 a.m.	127°	2:23.0 a.m.		224°
26	5.6	42 Aquarii	1:57.2 a.m.	105°	2:53.5 a.m.		228°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.



PHASES OF THE MOON

New moon.....May 4, 5:43 a.m.
First quarter.....May 12, 5:52 a.m.
Full moon.....May 19, 5:13 p.m.
Last quarter.....May 26, 9:33 a.m.

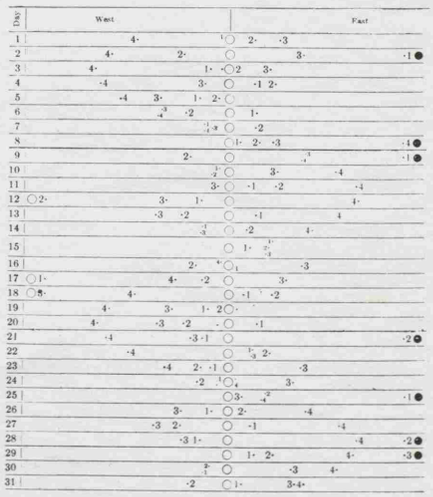
ANOTHER BRIGHT AURORA

On Monday evening, March 29th, a brilliant auroral display was observed from the northeastern part of the United States. A bright, green arch persisted throughout the evening, with variations in form and color, and at one time rays reaching the zenith almost gathered to form a corona.

JUPITER'S SATELLITES

On May 4th, the four principal moons will be west of the planet. On the 7th, after 11:37.2 p.m., and throughout the evening of May 14th, they will be on the east side.

Jupiter's four bright moons have the positions shown below at 11:15 p.m. E. W. T., the day preceding the date shown. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the American Ephemeris.



THE HARVARD BOOKS ON ASTRONOMY

Edited by HARLOW SHAPLEY and BART J. BOK
Harvard College Observatory

NEW ➡ *Atoms, Stars and Nebulae*

150 Illus.
323 Pages
$2.50
(1943)

This, the latest volume in the Harvard Series on Astronomy, gives the reader a thrill of discovery as he probes into the seething atmospheres of the stars and even digs into their interiors. It discusses single stars, double stars, dwarf and giant, cool and hot stars, stars that pulsate and some whose surface layers are suddenly wrenched away in cataclysmic stellar explosions. There is a fascinating discussion of stellar rainbows, atoms, molecules, etc. *By Leo Goldberg and Lawrence H. Aller.*

Between the Planets

106 Illus.
222 Pages
$2.50
(1941)

In summarizing our knowledge of comets, meteors, asteroids and meteorites, this book gives a description of the latest discoveries and considers the multitude of vexing problems yet unexplained. The history of comets, motions and numbers of asteroids, meteor showers, and so forth, are some of the subjects discussed. *By Fletcher G. Watson.*

Earth, Moon and Planets

140 Illus.
293 Pages
$2.50
(1941)

A concise, well-illustrated account of the planets and their atmospheres, with a discussion of the possibilities of life outside the earth, is presented in non-technical language. The reader is carried in his imagination below the clouds on Venus, Mars and the giant planets, into the depths of the earth and to the rough and airless surfaces on the Moon, Mercury and Pluto. A planet finder and star chart are included. *By Fred L. Whipple.*

The Milky Way

96 Illus.
204 Pages
$2.50
(1941)

This book presents in semi-popular form a summary of our present knowledge of the Milky Way and explains some of the problems which remain to be solved. The dust and gas in the vast spaces between the stars, the compositions and dimensions of star clusters, the appearance of our galaxy to an observer in the Andromeda nebula, and the problems related to the past and future of our galaxy are discussed. Two large scale photographic maps of the Milky Way and portraits of our leading scientists in the field are included. *By Bart J. Bok and Priscilla F. Bok.*

The Story of Variable Stars

82 Illus.
226 Pages
$2.50
(1941)

The Cepheid variables provide not only information about the deep interiors of stars but they also prove to be useful yardsticks for sounding the universe. This book introduces the reader to the technique of observation and then proceeds to analyze the present state of our knowledge of variable stars. A list of brighter variables, a Julian calendar and other useful tables are included. *By Leon Campbell and Luigi Jacchia.*

Philadelphia, Pa.

THE BLAKISTON COMPANY

COPERNICUS

1473 - 1543

COMMEMORATION · 1943 ·

ditto 1973

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THE COVER DESIGN AND ITS SYMBOLISM

THE ARTIST

This cover design was contributed by a refugee Polish artist, Arthur Szyk, perhaps the greatest living miniaturist working in the technique of illuminated medieval manuscripts. Although Mr. Szyk is best known to the American public through his striking caricatures of the leading characters of the so-called "New Order in Europe," yet among his best works have been those in which he portrayed some of the outstanding personalities in Polish and American history. His inimitable style and technique found an excellent expression in this portrayal of Copernicus, as no other artist could depict so many symbols within so few inches of space with so much meaning.

THE SYMBOLISM

Copernicus is represented here as a churchman and a scholar—more specifically, as astronomer. The chain and cap (with the Jagiellonian white eagle) are academic symbols. In the left hand he holds a device which illustrates one of his astronomical principles of planetary motions, with the sun in the center (see back cover: The Copernican Solar System and fuller explanation within). In front of him is an enlarged fragment of the Jagiellonian golden globe (see photographic reproduction of the original globe within).

In the upper left-hand corner is Wawel, the Polish Acropolis, with the center of Kraków as it looked in his student days (1491-95). In the upper right-hand corner is the coat-of-arms of the University of Kraków (*Universitas Cracoviensis*). The Roman numerals (1364-1400) indicate the years when the university was founded and renovated, respectively. On the table are the Holy Bible and the inkwell. Red and white are Polish national colors. The various texts speak for themselves—and their import is also made clear within this monograph. The lantern is such as he used on his observation tower at night.

Within the border design are:

At the bottom, the Polish white eagle of the Jagiellonian period.

In the left, coat-of-arms of Gniezno, the first capital of Poland.

In the right, coat-of-arms of Kraków, the capital of Poland in his student days.

At the top, coat-of-arms of his native city Torun.

NICHOLAS COPERNICUS

1543-1943

By STEPHEN P. MIZWA, A.M., LL.D.

THE KOSCIUSZKO FOUNDATION
NEW YORK

1943

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First Printing

PREFACE

THE AUTHOR IS, of course, fully conscious of the effort that he himself has contributed in the preparation of this booklet so that it would not offend the eye and yet retain some value—besides that of a mere souvenir—after it has served its present purpose. As measured by the demands of the subject and the occasion, he is also painfully aware that the result, such as it is, does not do full justice to the subject and may not completely fulfill the expectation of the occasion.

But the shortcomings would have been even greater, and certainly much more numerous, had it not been for the timely assistance of those to whom the author desires to express his gratitude. Thus, in the first place, to Dr. Henry Noble MacCracken, President of Vassar College and of the Kosciuszko Foundation, for having read the entire manuscript and for his encouragement and friendly advice. Secondly, to Dr. Oscar Halecki, the outstanding contemporary Polish historian, Professor of History at the University of Warsaw and now Director of the Polish Institute of Arts and Sciences in New York, for his careful scrutiny of the historical angles of this monograph. The outline map of Poland in the days of Copernicus was also prepared under his supervision. And no less to Dr. Edward Rosen of the City College of New York—our own leading Copernican scholar—for his perusal of the scientific phases and bibliographical suggestions and for his many helpful comments.

As a result of this triple revision, many an ambiguous word or phrase has been caught and eliminated, thereby giving the author a certain degree of courage to feel that the story he has told has gained a measure of reliability that could not otherwise have been achieved.

S. P. M.

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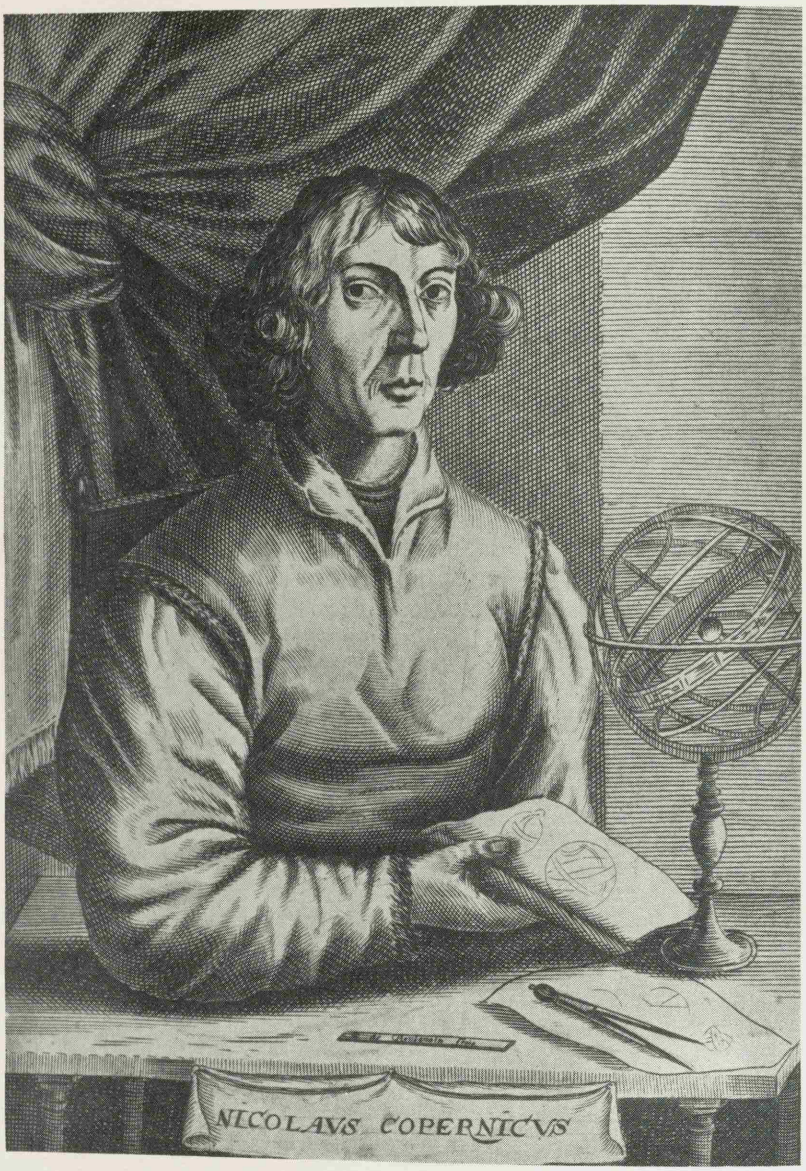
THE LIFE-STORY OF COPERNICUS

It has always seemed to me that the real significance of the heliocentric system lies in the greatness of this conception rather than in the fact of the discovery itself. There is no figure in astronomical history which may more appropriately claim the admiration of mankind through all time than that of Copernicus.

SIMON NEWCOMB[1]



NICHOLAS COPERNICUS

(From steel engraving by E. de Boulanois, Brussels, 1682)

Part I

THE LIFE-STORY OF COPERNICUS

MIKOLAJ KOPERNIK, best known by his Latinized name of Nicolaus[2]* Copernicus, was the most original and not the least versatile genius of Poland. He was a churchman, a painter and a poet, a physician, an economist, a statesman, a soldier, and a scientist; a churchman by the wish of his guardian uncle and by vocation, an artist for relaxation, a physician by training and predilection, an economist by accident, a statesman and a soldier by necessity, and a scientist — by the Grace of God and by sheer love of the truth for truth's sake. "Yet he found time," says the English historian of astronomy, A. M. Clerke, "to elaborate an entirely new system of astronomy, by the adoption of which man's outlook on the universe was fundamentally changed."

And today,—when for the first time in 575 years the Alma Mater of Copernicus has been closed by the invader, when the intellectual leadership of the nation is being extirpated and all visible monuments of Polish civilization destroyed,—today Copernicus stands like a shining star of hope to the nation that nurtured him, and the recollection of his abiding contribution gives his compatriots courage to endure.

COPERNICUS THE ASTRONOMER

Stripped of all scientific verbiage and reduced to the simplest elements, Copernicus's contribution in the field of astronomy

*All footnote references on pp. 57-59.

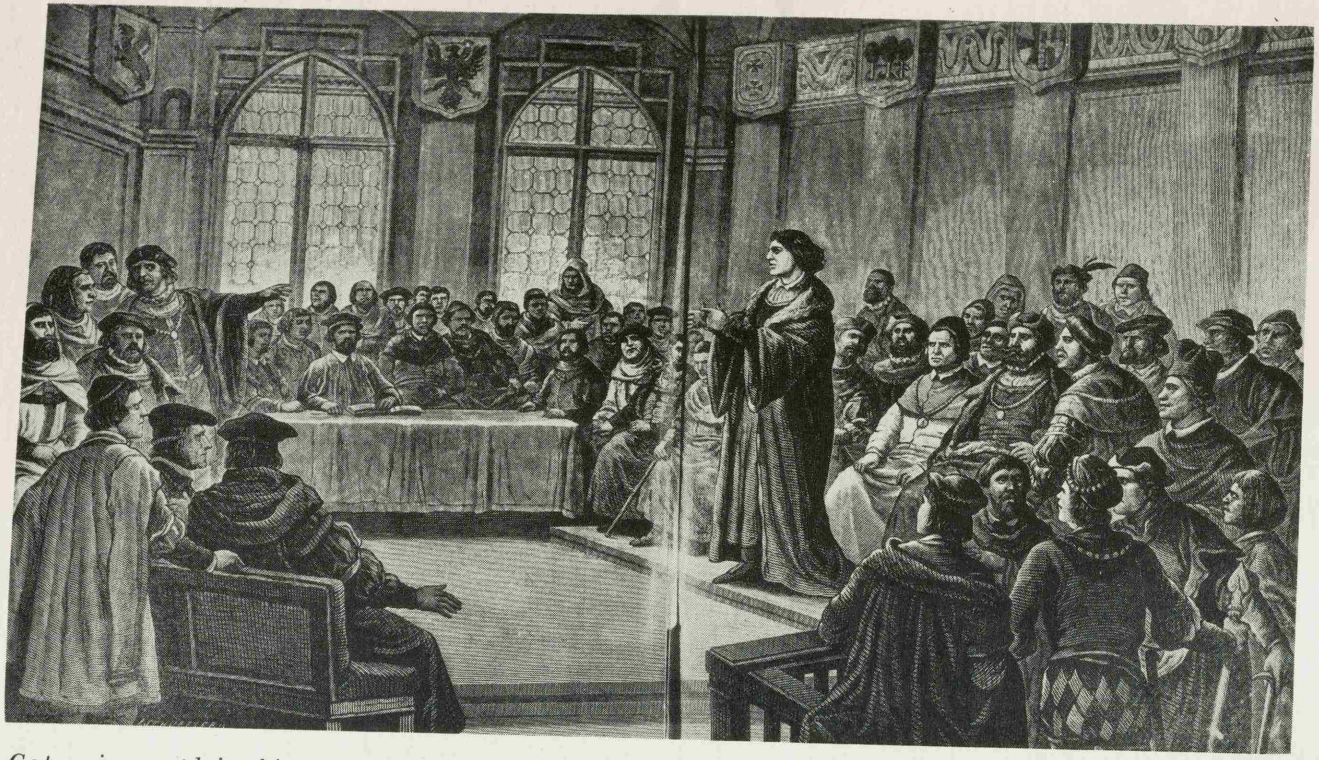
Nicholas Copernicus on the observation tower at the Cathedral of Frauenberg, by Jan Matejko (1838-93), the Polish national painter. The original oil painting was hanging till September, 1939, in the main assembly hall of the University of Krakow.

may be stated in the words: "He stopped the sun and set the earth in motion."

From time immemorial, ever since man began to peep through the crevice of his cave and noted the wonders of the heavens, the sun and moon and stars and their comings and goings, the behavior of celestial bodies had always been a mystery. Sages of the ages tried to adduce causes that would explain these phenomena perceived by the senses. Finally the Greek geographer and astronomer Ptolemy, who lived in Alexandria in the second century of our era, and who systematized the ideas and elaborations of all his predecessors, promulgated a system that was maintained and met no successful challenge for fourteen centuries.

It was a system based on the testimony of the senses, the geocentric conception, that supposed the earth to be the fixed center of the universe about which the sun and the other six planets revolve. That's what appeared to the eyesight as the sun rose and set and apparently moved round the earth, as the moon and other planets of the solar system changed their positions with respect to the earth.

It was the Ptolemaic geocentric system which prevailed until Copernicus bade the sun to stop, and at his bidding the earth began to spin. Contrary to the testimony of the senses, Copernicus completely reversed the system by superseding it with the heliocentric conception. In this new Copernican system the sun was the center round which moved the earth, the moon and other planets. Thanks to Copernicus and to his great work *De Revolutionibus Orbium Coelestium* (literally, "Concerning the Revolutions of the Heavenly Spheres") — the first copy of which its creator beheld with dimmed eyes on his deathbed—humanity got the key to the riddle which had been puzzling and troubling it for many thousands of years.



Copernicus explains his De Monetae Cudendae Ratio *(Concerning the Principle of Coining Money) at a session of the provincial diet in Grudziadz, 1522.*

By superseding the Ptolemaic geocentric system with his own, Copernicus, with his daring and fantastic imagination, gave us a new conception of this puny, tiny little vale of tears of ours we call the world and a new magnificent vista of the heavens above us and the universe around us. Even God and man assumed new meanings. The conception of distances could be transferred from the criteria of walking-time to those of millions of light years. Following the Copernican conception, it was discovered later that in our own solar neighborhood the earth is ninety-three millions of miles from the sun; Mars over one hundred and forty millions of miles; and Saturn over eight hundred eighty-six millions of miles. And those are only the nearest neighborly planets of our own solar system. Beyond this, there are millions of other solar systems, millions of light years away from ours. To use Copernicus's own words: "So large indeed is the divine workshop of the Almighty."

Copernicus the Economist

Copernicus the astronomer also made an important contribution to our knowledge of the monetary law, for which Sir Thomas Gresham (1519-79) got the credit in economic literature through an error made by the Scottish economist H. D. Macleod. In 1857 Macleod suggested the name of Gresham's Law as he was under the impression that the principle was first explained by Thomas Gresham in 1558.

Gresham's Law in economics—in brief, the principle that when bad money is in circulation with the good, the bad regulates the value of all and drives out the good—might also be called Copernicus's Law. For it was Copernicus who first formulated this principle with clarity in 1526 in his treatise *De Monetae Cudendae Ratio* (Concerning the Principle of Coining Money), 32 years before the promulgation of this monetary law by Gresham. To be sure, there was a French-

man in the XIV century named Nicole Oresme, who established a sound coinage for King Charles V (in 1355-58) and adumbrated Gresham's Law, but as Macleod himself later explained: "Copernicus wrote his treatise entirely without the knowledge of the preceding one of Oresme." And he spoke of Copernicus as "the founder of modern astronomy and one of the founders of a most important branch of economics."

It is not impossible that Copernicus might have known of Oresme's treatise, but the astronomer-economist formulated his law of bad money with a scientific precision not evident in any of his predecessors. Curiously, though a churchman, he attacked the problem not from the moral but from the realistic and social angles. Debasing the coinage was not a sin but bad economic practice which always brings about disastrous social consequences—in terms of rising prices. He did not use the word *inflation,* but realized its meaning and described its consequences. Debasing of the coinage, in his opinion, was one of four disasters that could befall a nation; the other three being discord, high mortality and poor harvests.

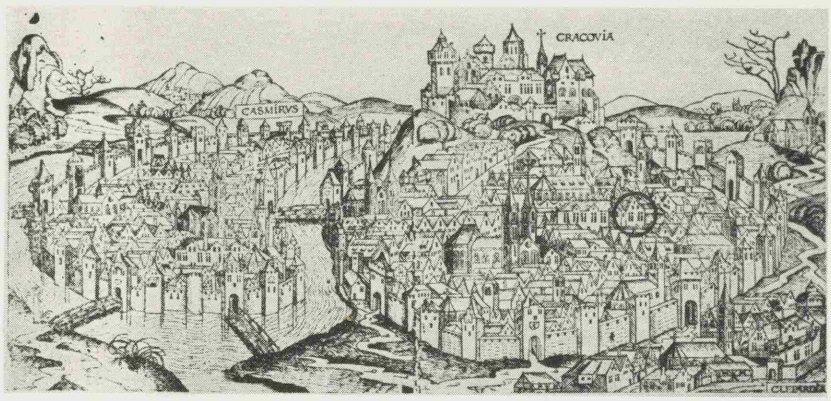
Churchman, Statesman and Soldier

A BIOGRAPHICAL SKETCH

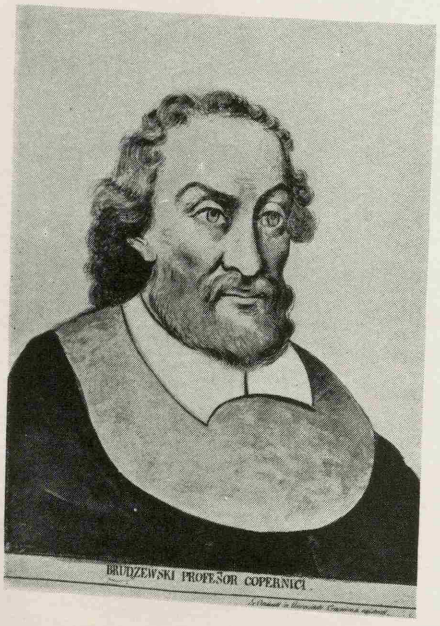
Nicholas Copernicus came of an old Silesian family. One of its branches moved (about 1350) to Krakow and in time became wealthy merchants in that ancient capital of Poland. When in 1454 the Union of Pomeranian territories and towns together with Danzig and Torun revolted against the Teutonic Order and asked the Polish king to take them back under the sovereignty of Poland, Nicholas Copernicus the Elder moved to Torun (about 1458) and it was here that the famous astronomer was born on February 19, 1473.

He spent his childhood in Torun and attended the Parochial School at St. John's Church. When his father died in

1483, he was put under the guardianship of his maternal uncle, later bishop and Polish Senator, Lucas Watzelrod, under whose tutelage he prepared himself for higher studies most probably in the Cathedral School of nearby Wloclawek. From 1491 to 1495 he studied at the ancient Polish University of Krakow.[3] Very little information has been preserved about the student days of Copernicus in this university—or in any university for that matter. Historians of astronomy are generally agreed, however, that while at Krakow he studied or came under the spell of that brilliant Polish astronomer and mathematician, Albert Brudzewski, or Wojciech z Brudzewa (1445-1495) as he is sometimes called, who was undoubtedly the first to inspire the young pupil in astronomy with the beauty of this old science. The first thrill that came to Copernicus from the handling of astronomical instruments and



View of Krakow in 1493, in the student days of Copernicus. In the center background is the Wawel (castle and cathedral), the Polish Acropolis; in the center, with two towers, is the famous St. Mary's Church, "from one of whose towers a trumpeter plays . . . the hejnal *every hour on the hour of day and of night"; to the left, across the river Vistula, is Kazimierz* (Casimirus), *a suburb which grew into a Jewish community. The location of the university is indicated by the circle.*



ALBERT BRUDZEWSKI
"the first great teacher of the great astronomer."

observation of the heavens was experienced in this "city of living stones".[4]

We happen to know that in September of 1494, i.e. during the last year of Copernicus's student days in Krakow, there were brought from Buda, Hungary, as gifts of Marcin Bylica[5] to the University of Krakow, four astronomical instruments. Primitive from our point of view but the last word in scientific equipment in those days, they were: a large celestial globe, two beautiful astrolabes and a *triquetrum*. The arrival of these instruments created such a sensation, we are told by documented histories of the university, that the Rector called a special student assembly to behold and admire these wonders. They have been preserved at the University of Krakow to this day. There is no doubt but that Copernicus was one of the most interested spectators.

We know much more about the first great teacher of the great astronomer. Albert Brudzewski, who was also a teacher

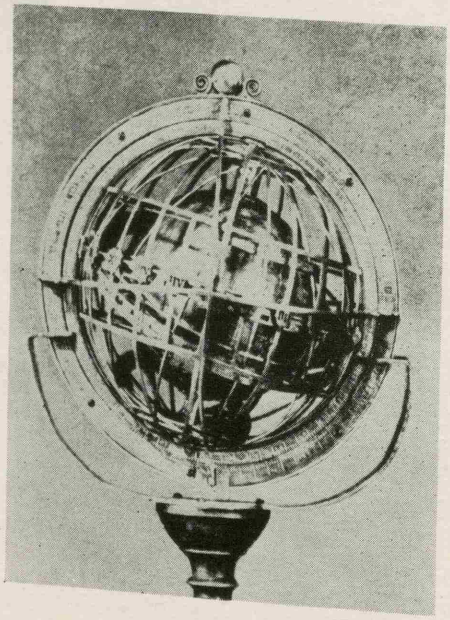
of Bernard Wapowski (a life-long friend of Copernicus and an eminent Polish historian), was one of the most active exponents of Humanism in Krakow. Although he taught the Ptolemaic system, he was a man of liberal sympathies and a "born teacher." He knew how to arouse his students' interests and encourage independent thinking. The discussions he provoked were often carried to the street, not infrequently ending in fist fights among students holding rival opinions.

For further study Copernicus went to Italy. At his uncle's request he enrolled as a student of canon law at Bologna University, but did not give up his scientific studies. Here he came in contact with the unorthodox astronomer Domenico Maria Novara (1454-1504). Although, thanks to his uncle's influence, he was elected a Canon[6] of Varmia (Ermland)—which gave him an independent income—Copernicus remained in Bologna to

While in Rome (in 1500), Copernicus observing an eclipse of the moon. From Louis Figuier, Vies Des Savants, *Paris, 1881.*

continue his studies and possibly astronomical observations. In the year 1500 he went to Rome, where he also lectured on mathematics and astronomy. While in Rome he observed an eclipse of the moon. From 1501 to 1503 he studied medicine at the University of Padua and at the same time obtained a doctor's degree in canon law at Ferrara.

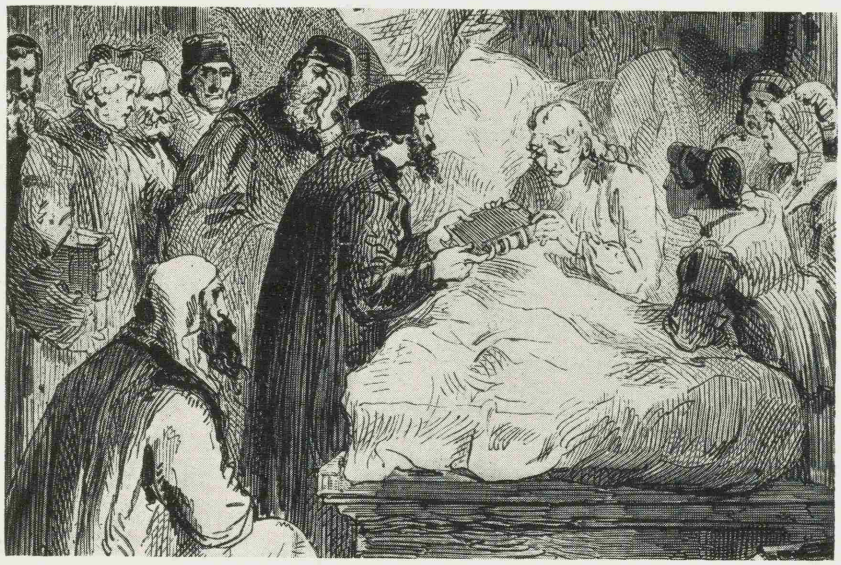
From 1504 or 1505 on he assumed his active duties as canon of the duchy-bishopric of Varmia, acted as physician and personal secretary to his uncle, Bishop Lucas, devoted much time to healing of the poor, continued his astronomical observations and took active part in political events of the day as the most inveterate enemy of the so-called Knights of the Teutonic Order, then headed by Albert of Hohenzollern (1490-1568), the last grand master of the Order. The latter was trying to create internal dissensions and foment disorders in the Polish provinces, especially in Varmia, which was surrounded by the



The famous "Jagiellonian golden globe," constructed about 1510, in the collection of the University of Krakow library. The first globe constructed on the Copernican theory of the motion of the earth, moved by a clock mechanism, on which the newly discovered American continent was placed with the legend: America terra noviter reperta *(America, the newly discovered land). An enlarged fragment of this globe is reproduced by Mr. Szyk in the cover design.*

Teutonic possessions on three sides.[7] When war with the Teutonic Order broke out in 1520, Copernicus the churchman, physician and astronomer, became commander in chief of his beleaguered city of Olsztyn (Allenstein). Soon after that, at the request of Sigismund I, King of Poland, he took active part in the currency reforms of Varmia and neighboring provinces.

It was at this post as administrator of church property of the duchy-bishopric of Varmia, not infrequently interrupted by political activities and armed conflicts, that Nicholas Copernicus labored, observed and tabulated his data the rest of his active life—culminating in *De Revolutionibus*—and it was here that after exhaustion, paralyzed, deprived of memory and consciousness, he passed on to his eternal reward on May 24, 1543.



"De Revolutionibus Orbium Coelestium—*The first copy of which its creator beheld with his dimmed eyes on his deathbed.*"

Illustration from Louis Figuier, Vies Des Savants, *Paris, 1881.*

Slow Recognition of the New Truth

"His theory," says Dr. Dorothy Stimson in her scholarly study *The Gradual Acceptance of the Copernican Theory of the Universe,* "is a triumph of reason and imagination and with its almost complete independence of authority is perhaps as original a work as an human being may be expected to produce."

Yet in spite of this, or rather because of it, the very publication of Copernicus's *De Revolutionibus* was a tragedy in itself; and after publication, the new truth had to struggle for recognition and acceptance for over two hundred years.

Audacious as a thinker and not lacking even in physical courage, Copernicus was timid in pushing his own discoveries. He wanted to work out, check and recheck, all details before eventual publication. "When therefore I had pondered these matters," he explained later in his dedication, "the scorn which was to be feared on account of the novelty and the absurdity of the opinion impelled me for that reason to set aside entirely the book already drawn up." The testimony of the senses was against him and he was also afraid that the Church, of which he was a faithful son, might take exception to his revolutionary theory.

Finally, when he was persuaded by a young astronomer and disciple of his, George Joachim Rheticus of Wittenberg, to have his priceless manuscript published in Nuremberg, the proofreading was unfortunately entrusted to Andreas Osiander, who was not worthy of the confidence placed in him. In order to mollify possible opposition of the Church and perhaps enlist its support in the promulgation of the new truth, Copernicus wrote a splendid dedicatory letter to Pope Paul III intended as a preface to *De Revolutionibus.* Having previously failed to persuade Copernicus to write an introduction explaining that the new system is merely a hypothesis,

useful for calculations but not necessarily true, Osiander now took advantage of Copernicus's illness and anonymously inserted a foreword of his own, at the same time suppressing the author's introduction to Book I. Fortunately Copernicus was spared the agony caused by betrayal as his dim eyesight did not catch this anonymous foreword. For years it was thought that it was Copernicus who wrote this "Osiandric" foreword in order to disarm criticism. Perhaps, unwittingly, Osiander rendered a much greater service than he realized for the preservation of this great work. Because of this spurious and disarming foreword, cleverly addressed, as though in the name of the author, "to the reader of the hypotheses of this work" *(ad lectorem de hypothesibus huius operis),* the Church overlooked the revolutionary importance of *De Revolutionibus* and did not put it on the Index till 1616. It remained on the Index until 1835.

In the Protestant countries the general acceptance of the Copernican theory was somewhat accelerated but not too perceptibly. It should however be observed here, to the credit of his Church, that although it was slower in accepting the Copernican system as established scientific truth, it neither persecuted its creator nor exposed him to ridicule. This much cannot be said of the contemporary religious reformers, who were less tolerant. Martin Luther (1483-1546) referred to Copernicus as the "new astrologer," concerning whose contribution his judgment was: "The fool will overturn the whole system of astronomy."[8] Indeed he did. It took one hundred and fifty years for *De Revolutionibus* to be approved by European scholars and mathematicians; another generation more before the Copernican system was openly taught at Oxford, Sorbonne and at Yale; and two generations after that before the common people were ready for this revolutionary conception.

It is worthy of note that in our Colonial America, as early

as 1721 Cotton Mather conceded that the "Copernican hypothesis is now generally preferred," and that "there is no objection against the motion of the earth."

The Death of Copernicus—and the Birth of Modern Science

Copernicus lived, worked and died in that period which is generally regarded as a transition from the so-called middle ages to modern times. It was a period of the revival of learning and of the birth of modern science.

In art and literature there was recovery of classical culture and its revitalization and adaptation to Christian civilization. In the relationships of groups of men this period saw the dawn of modern nationalities, although only a bare adumbration of the dawn, as well as the birth of modern languages. The restless spirits launched upon exploration of the unknown and discovery of new continents.

In science especially there was a change of outlook and of manner of approach in quest of new truths; a change from meditation to experimentation. Men began to question that which was handed down to them as unquestionable and commenced to find out for themselves—not through excogitation but through observation, by objective standards, by weighing and measuring. It was in this transitional era that the Copernican system of astronomy was inaugurated and finally replaced the Ptolemaic system.

Leonardo da Vinci (1452-1519), the great Italian painter and natural philosopher, who constantly poked around trying to discover the hidden laws of nature, was a contemporary of Copernicus; his immediate successors were the celebrated English experimental philosopher, Francis Bacon (1561-1626), and Galileo (1564-1642), another great Italian, astronomer and physicist. Equipped with the newly invented telescope (gen-

erally accepted as in Holland, 1608), which he improved, Galileo carried on astronomical observations where Copernicus left off.

Tycho Brahe (1546-1601), the Danish astronomer, who was born only three years after the death of Copernicus, also deserves special mention. He was not only one of Copernicus's immediate successors, but also one whose painstaking observations and calculations proved the fundamental truth of the Copernican system. If Copernicus is the father of modern astronomy from the viewpoint of its fundamental heliocentric conception, Tycho Brahe may justly be called the father of modern practical astronomy.

If "the proper study of mankind is man," William Harvey (1578-1657), the English physician who discovered the circulation of blood, approached the study of man in a scientific manner and laid the foundation for the modern sciences of physiology and biology.

Different branches of modern science had different birthdays, but directly or indirectly their origins may be traced to the Copernican era. His treatise "Concerning the Revolutions of the Heavenly Spheres" gave birth to revolutions in other branches of science besides astronomy. Thus, as the civilized world of today pays tribute to Copernicus, it may appropriately regard this anniversary as the quadricentennial of modern science.

DIALOGVS
DE SYSTEMATE MVNDI,
Autore
GALILÆO GALILÆI LYNCEO,
SERENISSIMO
FERDINANDO II. HETRVR. MAGNO-DVCI
dicatus.
C. PTOLEM.
ARISTOT.
N. COPERNICVS.
Anno S.
Augustæ Treboc.
Impensis BONAVENTVRÆ et ABRAHAMI ELZEVIR
Bibliopolar Leydens.
1637

The title page of Galileo's famous Dialog about the two Principal Systems of the Universe *(Ptolemaic and Copernican), 1635 edition, first published in the Italian in 1632. The engraving shows Aristotle, Ptolemy and Copernicus. Out of over 300 known likenesses of Copernicus, most of them variations of only a few probably authentic portraits, this is one of the very earliest.*

*In the left hand Copernicus holds a device, with which he is often portrayed, illustrating one of his astronomical principles of planetary motions. The sun in the center, around it a large circle of planetary motion, and around that, in turn, another planet moving in a smaller circle or epicicle. The late Prof. Ludwik A. Birkenmajer introduced a new word—*concentrobiepiciclic*—which is descriptive of the principle and which has been generally accepted by scientists.*

In the days of Galileo the Copernican theory was still a revolutionary and dangerous doctrine, upheld only by the most daring spirits at the risk of their own safety. Galileo's Dialog, *which favored the Copernican system in a very subtle but masterly manner, created such a tumult of applause throughout Europe that it brought its author before the Inquisition for the second time; this time resulting in imprisonment in his own residence for the rest of his life. However, he was not burned at the stake as some people still erroneously believe.*

Photostatic reproduction of the title page of Nicholas Copernicus's De Revolutionibus Orbium Coelestium *first edition (1543). Notations in long hand, and at bottom in print, tell the complete story of its peregrination. The writing at the bottom, later crossed out, says in Latin:* Reverendo D. [domino] Georgio Donder canonico Varmiensi amico suo Joachimus Rheticus d:d:. *Meaning: "To Reverend Mr. George Donder, Canon of Varmia, from* [or to] *his friend Joachim Rheticus." The initials* d:d: *stood for a Latin dedicatory formula—*Donat Dedicat. *This dedicatory inscription was later crossed out and, in another hand, above, we see the legend:* Collegii Brunsbergensis Societatis Jesu. *This copy was apparently donated to the Jesuit College of Brunsberg (present Baunsberg) in Varmia. The college was still in existence in 1939 as* Lyceum Hosianum. *It was founded, after 1551, by the Polish Cardinal, Stanislaw Hozjusz (1504-1579), who was then Bishop of Varmia. Carried by Gustavus Adolphus to Sweden in 1626, the book found its way finally to the Library of the Royal University of Uppsala, Sweden. One copy of the first edition is also in possession of the New York Public Library.*

NICOLAI CO
PERNICI TORINENSIS
DE REVOLVTIONIBVS ORBIum cœleſtium, Libri VI.

Habes in hoc opere iam recens nato, & æditò, ſtudioſe lector, Motus ſtellarum, tam fixarum, quàm erraticarum, cum ex ueteribus, tum etiam ex recentibus obſeruationibus reſtitutos: & nouis inſuper ac admirabilibus hypotheſibus ornatos. Habes etiam Tabulas expeditiſsimas, ex quibus coſdem ad quoduis tempus quàm facillime calculare poteris. Igitur eme, lege, fruere.

Ἀγεωμέτρητος μηδεὶς εἰσίτω.

Collegij Brunsbergensis Societatis Iesv.

Norimbergæ apud Ioh. Petreium,
Anno M. D. XLIII.

Reuerendo D. Georgio
Donner Canonico Varmiensi
amico suo plurimum
Copernicus S.D.

Kgl. Univ. - Biblioteket, Uppsala

SARMATICUS ASTRONOMUS

No. 2391. 16. Oct.

B. Mithobio.

Epist. lib. II. p. 333 sqq. (edit. Lond. lib. II. ep. 337.)

D. Burcardo Mithobio.

S. D. Et optarim te hac iter facere, et venienti multa de insidiosissimis actionibus narrarem, et de caeteris rebus, quae literis committi non possunt. De concionatore cum *Luthero* et D. *Pomerano* deliberabo, quos scio cupere optime consultum Ecclesiis vestris, et Illustrissimam Dominam*), piis votis Deo commendare. De monasteriis quod significas, quosdam esse cunctantiores, relinquamus illis suam sapientiam, fortassis volunt σπεύδειν βραδέως, etsi saepe iam magno cum dolore expertus sum, admodum esse inconstantes τῶν ἀρχόντων animos. Vos initio pugnate, ut populi Ecclesiae, seu, ut vocantur, παροικίαι bene instaurentur et constituantur. Plerique Principes etiam ante hoc tempus multo fuerunt in diripiendis Monasteriis diligentiores, quam in constituendis παροικίαις et scholis. Sed expectemus venientem annum, qui fortassis excutiet nostris Heroibus veternum, ludos, voluptates, amores, rixas. Hactenus alii saevierunt in Ecclesias, alii finxerunt corruptelas doctrinae, certarunt obscoenis libellis; finxerunt insulsos dialogos, oblectarunt se Venereis voluptatibus, neglexerunt Ecclesias et scholas, certarunt ambitione. Nunc Nemesis attrahit non contemnendum hostem. Sed oremus Deum, ut tegat Ecclesias et nostros etiam ad vera τῆς θεοσεβίας officia exuscitet. Vidi dialogum, et fui dissuasor editionis. Fabula per sese paulatim consilescet; sed quidam putant esse egregium κατόρθωμα rem tam absurdam ornare, sicut ille Sarmaticus Astronomus**), qui movet terram et figit Solem. Profecto sapientes gubernatores deberent ingeniorum petulantiam cohercere. Bene vale, die 16. Octobris.

Page 679 of vol. IV of Corpus Reformatorum, *containing a letter (of Oct. 16, 1541) from Philipp Melanchthon to a Mr. Burcard Mithobius, with first historic reference to "that Sarmatian astronomer who is trying to stop the sun and move the earth." The underscoring is that of the present writer. The two stars after* Astronomus *were inserted by later Editor, Bretschneider, giving the name of Copernicus in the footnote—not shown in this photostatic copy.*

Part II

SARMATICUS ASTRONOMUS

Sarmaticus Astronomus,
qui movet terram et figit Solem.

—PHILIPP MELANCHTHON

Wstrzymal slonce, wzruszyl ziemie,
Polskie wydalo go plemie.

"The sun he bade to stop, and at his bidding the earth began to spin—Poland has nurtured him."

EVER since the scientific world rediscovered Copernicus and the Polish nation built a public monument in Warsaw to honor the great astronomer, the Germans at first began to question his Polish nationality and then even advanced arguments that he might have been German. Their arguments have been: that he spelled his name with a double "p" (Coppernicus or Koppernigk); that Silesia, the land whence his ancestors came, is German; that Torun (Thorn), the place of his birth, and Krakow (Cracow), the Polish center of learning where he received his first university education, are German cities; that everything worth-while in Poland is German.

Prior to the XIX century, there was no question of Copernicus's nationality. The first testimony we have about his Sar-

matian ancestry comes from no other than the great German theologian and reformer, Philipp Melanchthon (1497-1560), who derisively referred to his contemporary scientist as "that Sarmatian astronomer, who is trying to stop the sun and move the earth"—calling the whole conception such an absurd notion *(rem tam absurdum)*.[9] It is not our purpose here to enter into polemics with a view of proving or disproving German claims, either of territorial or cultural implications. But rather, within the limited space at our disposal, to collate such information as would enable the reader to have a better understanding of the family and territorial backgrounds of our subject.

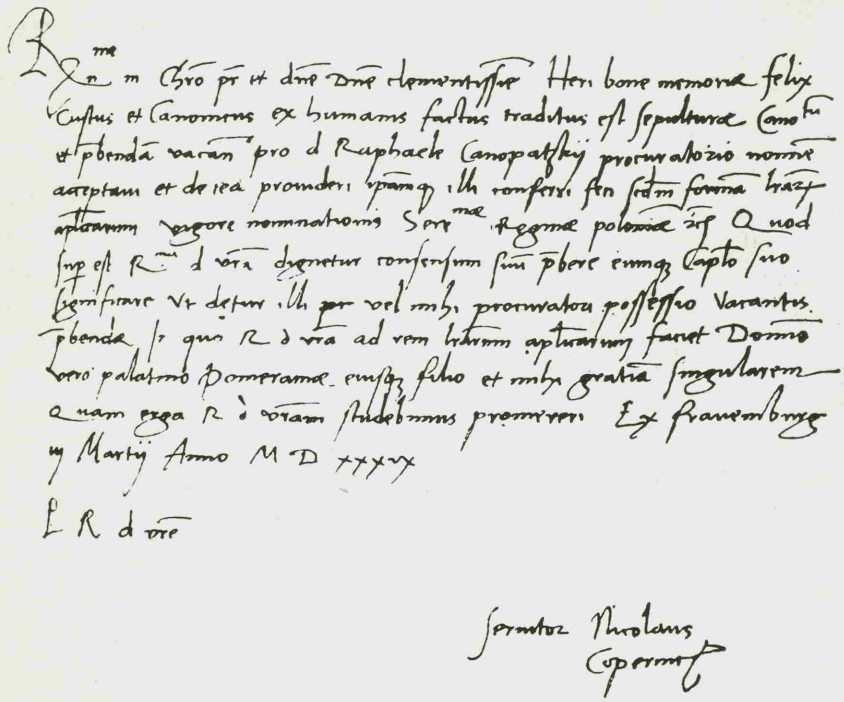
The Cradle of the Family: Silesia and Krakow

There are some things about the life, relationships and associations of Copernicus that we are quite sure of and have documentary evidence for; there are other things that we do not know all about, and volumes of words set forth in many languages have not given us as yet a complete answer; and there are still other things that are buried in the pre-historic past and perhaps will never be known.

Copernicus is a simplified Latin version which he himself assumed and finally used. It is not the name, in its final form, that he took from his father and used all his life. In his younger years he would sign himself most frequently as Coppernic or Coppernicus; in his later years, with a single "p"—in the Polish version Copernic, and in Latin version Copernicus. His brother Andreas spelled it still differently. Names in those days were not typewritten or spelled out. They were entered by scribes approximately as they sounded; and when copied, changes occurred. What the name intrinsically means, where

it comes from, its changes and evolution, we shall briefly discuss later.

But we are certain that his ancestors came from (originally Polish) Silesia and that his great-grandfather became a citizen of Krakow in 1396. We know that from an official document of Krakow for the year 1396 which states that, "Nicolaus Koppirnig received the right of citizenship. Dambraw[10] vouched for his birth certificate." In the absence of actual birth certificate the testimony of a respectable local citizen was sufficient. The founding of Krakow, incidentally—like that of Rome—is enveloped in myth and tradition. When contem-



A specimen of Copernicus's handwriting and signature in the year 1539.

porary sources mention Poland in the tenth century, Krakow was already a stronghold. Boleslaw Chrobry (966-1025), the first crowned king of Poland, made it the seat of a bishopric in the year 1000. Silesia on the other hand, especially that part of Silesia from which Copernicus's ancestors came to settle in Krakow, was a land contested by the Slav and the Teuton for many centuries. Originally it was inhabited by two Slavonic tribes *(Slezanie* and *Opolanie)* out of which, together with other tribes to the east and northeast, arose the historic Poland in the tenth century. From the tenth to the fourteenth century Silesia was ruled by princes of the original Polish Piast dynasty, then passed under Bohemian suzerainty, and later under Germany. Blood and names of the former inhabitants thereof are hidden in nebulous past of the pre-nationalistic and even pre-historic era.

The Name Kopernik and Its Meaning

Not far northwest from Katowice there is still (or was in recent times) a parish village by the name of Koppernig, whence the ancestors of Copernicus came. The name of the village, not unlike that of the astronomer's family, has been variously spelled. A large German atlas of Silesia, published by Wieland in Nuremberg in 1731, spells it Kopernik.

While at present towns and villages often are named after their founders, formerly it was the residents—when they moved to other places—who were frequently named after towns and villages of their former domicile. Thus George Joachim (Rheticus), the contemporary admirer of Copernicus, was named after his native province of Rhaetia. That the family name of Kopernik comes from the village by that name, or closely resembling it in spelling or sound, of that we are fairly certain. But there are differences of opinion as to the origin of the name of the village itself. There are at least two

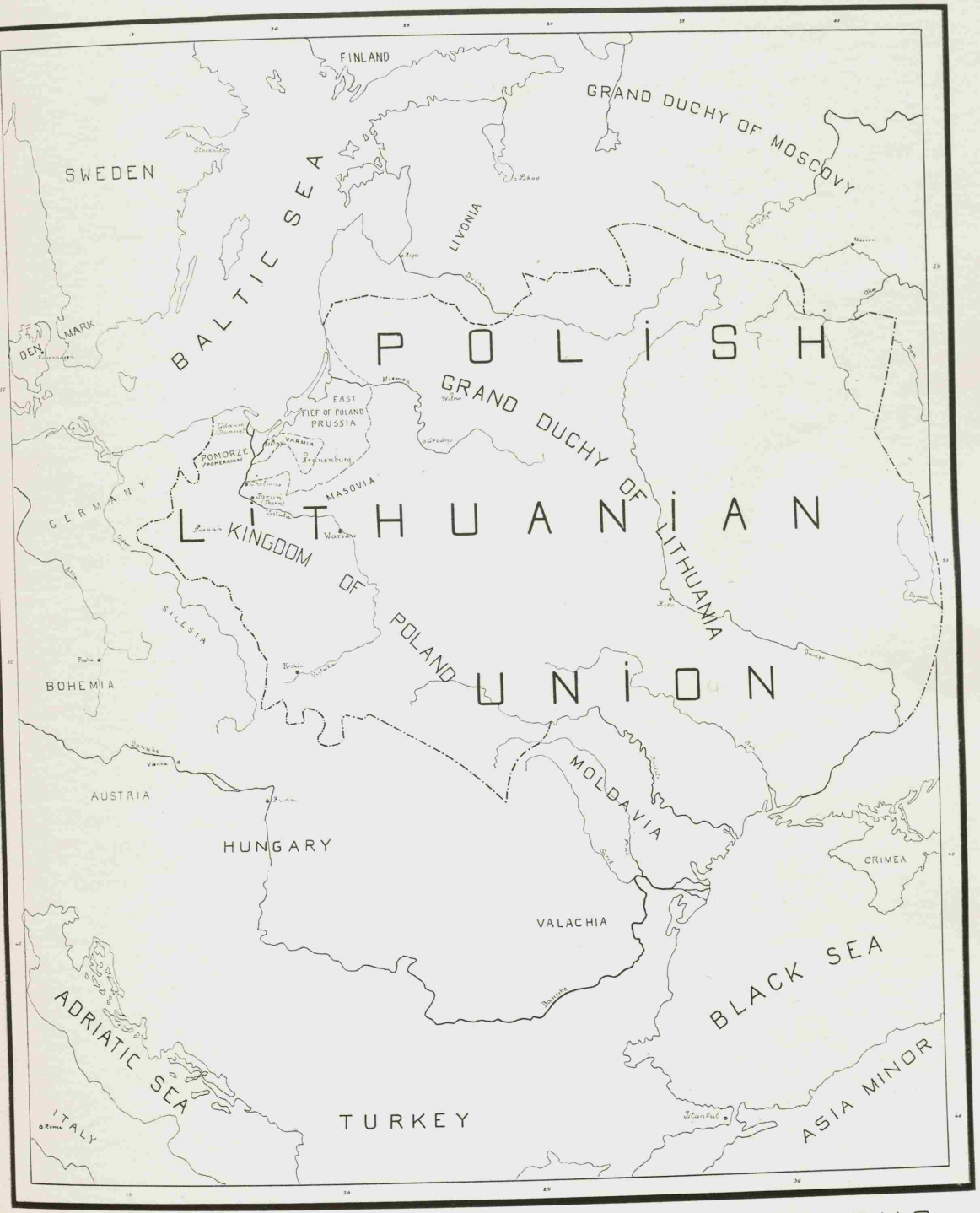
plausible explanations. One interpretation is that it comes from the occupation of coppersmithing—from Latin *cuprum,* through German *Kupfer.* Kopernik in old Polish also meant a dealer or worker in metal, more particularly in copper. When the Polish Piast princes invited German colonists (or the latter came uninvited) to settle in Silesia, they must have introduced coppersmithing, from which industrial occupation the village probably took its name. In fact Nicholas Copernicus comes of a family of merchants with a long tradition in metal trading. The earliest (1448) extant information about his father shows that he was a merchant in Krakow and a dealer in copper—buying it in Hungary and selling in Danzig and Torun. Another plausible explanation is that the name of the village comes from a plant that was profusely growing there. Kopernik, Koperek, Kopr and Koprnik in Polish—also similarly in other Slavonic languages—means simply dill such as is used in dill pickling. Be it as it may, although the present writer is inclined more towards the occupational interpretation, it is interesting to note that the family name of the great astronomer's ancestors was variously spelled but always in close resemblance to the sound of the Polish or Slavonic dill, viz.: Coprnik, Copirnik, Copernik, Copernick, Koprnik, Kopirnik, Koppirnik, Koppernik, Koppernigk, Kopernik—plus a few other variants.[11] Names seem to have curious fashions of their own; Shakespeare's name has been spelled differently, Smith and Brown have had their variants; and even Field in England was once Feild.

"On the Mother's Side"

On the mother's side our astronomer's ancestral antecedents cannot be traced with the degree of certainty with which we followed his male lineage from Silesia to Krakow, then to Torun. However, contemporarily the family was well known.

Nicholas Copernicus or rather Kopernik, the Elder, married (between 1461 and 1464) a Barbara Watzelrod, the daughter of a patrician merchant of Torun, Lucas and Katherine Watzelrod. This name has also had many variants: Watzelrode, Weisselrode, Watzelrod, Wazelrod, Waczelrod, Waczenrod, Wacelrod, etc. There is no certainty as to where this family came from. Some advance the theory that it came originally also from Silesia; others, that it came from East Prussia; still others, that it is an old Masovian Polish family. A local German historian, Gottfried Centner (1712-1774), who also devoted considerable attention to genealogies of prominent Torun families in the past, says that the astronomer's mother's mother (grandmother Katherine) came of the family of Modlibog.[12] If that be so, Modlibog (in Polish, literally, *Praygod)* is a family well known in the history of Poland since 1271.

Family names on both the father's and mother's side disappeared with the death of Nicholas Copernicus and his uncle, Bishop Lucas Watzelrod. Nicholas Copernicus or Kopernik, the Elder, and Barbara Watzelrod had four children, two sons and two daughters. Both sons, Andreas and Nicholas, were churchmen and therefore unmarried and left no descendants. Lucas Watzelrod and Katherine Modlibog, the astronomer's maternal grandparents had only one son Lucas,[13] our friend Bishop of Varmia. That the Watzelrod family was distinguished, is reflected in the provincial records. Of Lucas Watzelrod, the Elder, they have this to say: that he was "devout and honest" (this much apparently could not be said of other merchants), that he was "a faithful servant of the Polish king," that he fought valiantly and must have been well-to-do as he advanced his own money for the defense of the city; and of his spouse, Katherine *née* Modlibog, that "she was the crown of all Torun beauties."



POLAND IN THE DAYS OF COPERNICUS

"Prussian Poland," Torun and Varmia

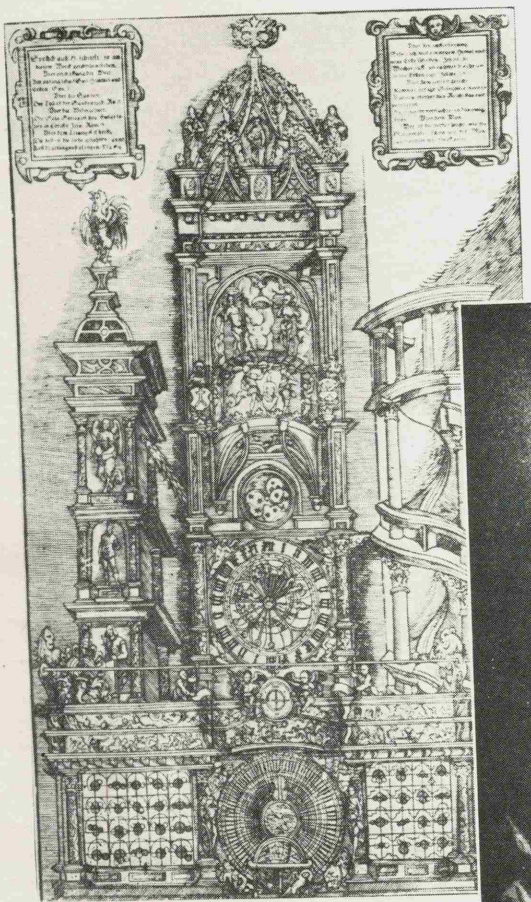
A. M. Clerke, in Encyclopaedia Britannica on Copernicus, says: "Polish astronomer . . . born . . . at Thorn [Torun] in Prussian Poland." Also gives one of the variants of the name: Koppernigk. All the facts here are correct. It may be added, however, that this "Prussian Poland" or Polish Prussia is Pomorze in Polish, the so-called *Polish Corridor*. But some writers, knowingly or unknowingly, have dropped the word "Poland" and turned the adjective "Prussian" into a noun Prussia. The conclusion seemed to follow then that if Copernicus was born in Prussia, he was Prussian and being Prussian, he must have been German.

A few words about the territorial complex with which Copernicus was associated as a child and then as mature man —i.e. about "Prussian Poland" and Varmia—are essential for better orientation. Let us therefore take a little side trip into that historic "Corridor." Time was when there was no such thing as Prussia, or West Prussia, in the modern sense. For a long time Polish princes and kings ruled in Pomorze, including Masovia where Torun now stands. To the southwest of Pomorze, formerly pastureland and hunting ground of Slavonic tribes, was the Mark of Brandenburg; to the northeast, later known as East Prussia, there lived a pagan Baltic tribe (akin to the Lithuanians) called the Prussians. The Polish Duke Conrad of Masovia had considerable difficulty with these pagans, who frequently would pillage his borderland and kill off the inhabitants. To help him protect his Polish territory against the inroads of these savage Prussians from the northeast, Conrad invited (in 1225/6) the Knights of the Teutonic Order to settle in the district of Chelmno (Kulm) on a "lend-lease" plan. This cure proved much worse than the disease as it turned into the story of the Arab and the camel. These Teutonic Knights exterminated most of the original Prussians,

settled the territory (East Prussia) with German colonists, and then turned on their hosts the Poles. They conquered the Polish Pomorze province, including Danzig, and also severed from Poland the Chelmno district, with its center of Tarnowo (meaning in Polish the little town or village of Tarnow), whose name they changed in 1231-33 to Thorn (through Tarn, Torn to Thorn)[14] and which they held until the rebellion against the Order in 1454-66. After the Treaty of Torun of 1466, this city with the entire Pomorze, then called Royal Prussia (later West Prussia), and a part of East Prussia, the duchy-bishopric of Varmia or Ermland (of which Copernicus was a canon), came under Poland where they remained until the first and the second partitions, when they were incorporated in the new Kingdom of Prussia: Varmia and most of Pomorze in 1772, Torun and Danzig in 1793. Torun was afterwards temporarily (1806-15) attached to the Grand Duchy of Warsaw, but in 1815 was granted to Prussia, in which it remained till 1918. The State of Prussia, which played such a large part in the history of modern Germany, arose from the combination of the Mark of Brandenburg and the State of the Teutonic Order in East Prussia, from which the general name was derived. Somehow the name Prussia lingered through historical writings, and "Polish Prussia" or "Prussian Poland" has often been used by foreign writers and historians as synonyms for the Polish Pomorze.

"Writing on the Wall" and Other Mementos

The Cathedral of Frauenburg in the duchy-bishopric of Varmia, had fortifications and towers. One of the towers Copernicus used for his laboratory and astronomical observatory, now known as the Tower of Copernicus *(Turricula Copernici)* which has been turned into a small museum.



(Above) A contemporary wood cut of the Astronomical Clock Tower of the Cathedral of Strasbourg.

(Right) Copy of selfportrait of Nicholas Copernicus, done by Tobias Stimmer, in 1571, on the Astronomical Clock Tower of the Cathedral of Strasbourg. Lily of the valley may be a symbol of Copernicus's interest in natural philosophy, more particularly in medicine.

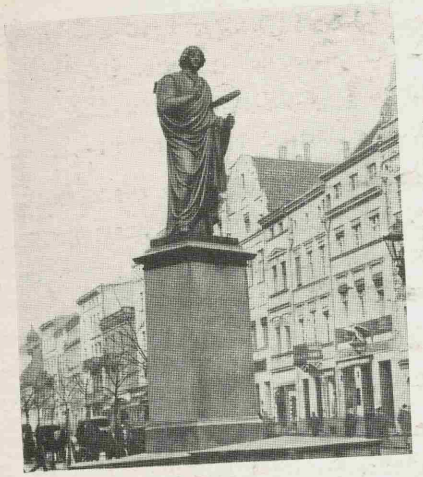
Among the mementos there are: a few works from the astronomer's personal library, one set of astronomical tables by Johann de Regio Monte or Regiomontanus (1436-1476) with notes and drawings made by Copernicus, and a piece of an old bent and rusty pipe which he allegedly used as a telescope.

In the Bishop's Chateau at Olsztyn (Allenstein) where Copernicus stayed in 1517-19, 1521 and 1525 during his travels as Canon of Varmia, there is a room which he occupied. On the walls of that room, telltale evidence of his occupancy is offered by scribblings and astronomical notations in his own handwriting. Whenever ideas came to him, he would put them down on margins of books, calendars, and even on walls. This might have been a habit which he acquired during his student days, especially if he lived in a dormitory. . . . Be it as it may, such notations enabled the outstanding Copernican scholar, the late Professor Ludwik A. Birkenmajer who devoted his lifetime for this purpose, to recreate the genesis and progress of the Copernican system—from the last year of Copernicus's student days at the University of Krakow up to the composition of the *De Revolutionibus*.

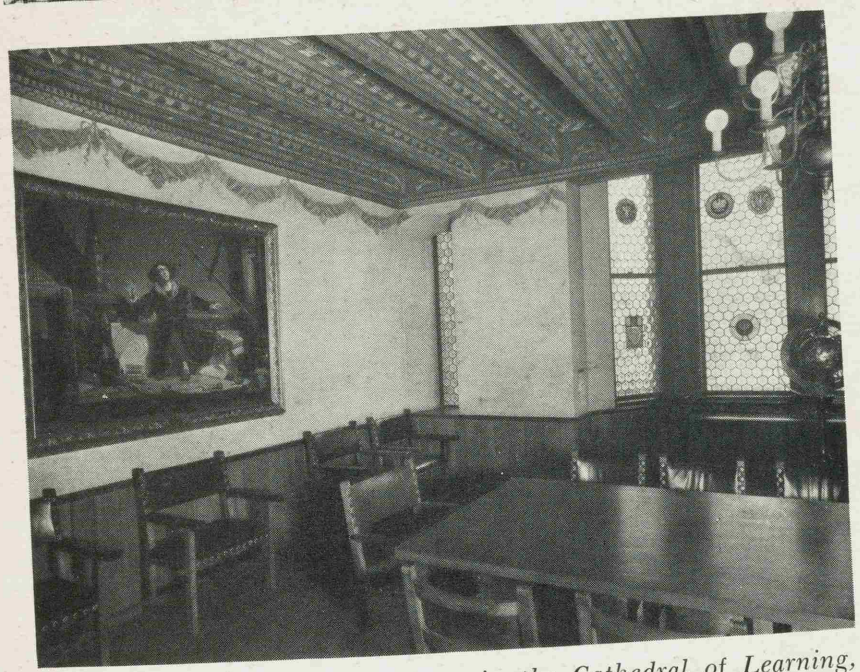
We stated in the beginning that Copernicus was also an artist. He was; but how good, we do not know. The only evidence we have of his artistic efforts is indirect: a copy of his selfportrait. The original painting or drawing was sent from Danzig by Dr. Tidemann Gise to Tobias Stimmer, who reproduced it (about 1571-74) on the famous astronomical clock tower of the Cathedral of Strasbourg (Strassburg).

There are schools, streets, monuments, tablets and plaques commemorating Copernicus in all sections of Poland. The University of Bologna, already in our time, ordered a Copernicus bust from a Polish sculptor. Hamtramck, Mich., which has a large population of Polish ancestry, gave its sumptuous

"In the year 1500 he went to Rome, where he also lectured on mathematics and astronomy." Although the painter, Wojciech Gerson (1831-1901), has a number of prominent contemporaries present at the lecture (including such celebrities as Leonardo da Vinci, Pope Alexander VI and the astronomer Domenico Maria Novara from Bologna University), it cannot be proved that all of them were present at one time.



The Copernicus monument which the Germans erected in Torun, "as a demonstrable and demonstrative reminder to the Poles that Torun and its inhabitants, great and small, have always been and will also be German."



View of the Copernicus classroom in the Cathedral of Learning, University of Pittsburgh. On the wall, to the left, is a copy of the famous painting of Copernicus by Jan Matejko. To the right is a replica of the Jagiellonian golden globe, presented by the Polish National Alliance of America.

Junior High School the name of Copernicus. The University of Pittsburgh has a Copernicus classroom in the Cathedral of Learning. Formerly the desire to commemorate the great astronomer was as slow as the acceptance of his theory.

We shall outline briefly the most characteristic memorials that were written or erected in honor of the famous astronomer through the past four centuries; the earliest, for the most part, consisting of writing on the wall.

He was buried in the Cathedral of Frauenburg near the main altar, and over his grave was placed a simple flagstone on which some kind hand had chiselled out the following simple inscription: "Nicolaus Copernicus died in the year MDXLIII." About fifty years later Marcin Kromer, a Krakovian, Polish historian and statesman and a bishop of Varmia, had a suitable memorial tablet built into the wall of the cathedral; but this tablet was removed by some unknown hand around 1732-34. Further attempts at more imposing commemoration in monuments or plaques on the part of Varmian canons and bishops, including that of Bishop Ignacy Krasicki (1735-1801), resulted only in monumental good will. Also towards the end of the XVI century, a physician and well-to-do citizen of Torun, Melchior Pyrnezjusz, originally from Krakow, erected a Copernicus statue in the St. John's Church in Torun and over the statue put the following characteristic inscription in Latin: "To Nicholas Copernicus of Torun, so renowned in other lands, this monument is erected so that he may not be forgotten in his own motherland." In 1733 a councilman of Torun, Jakob Kazimierz Rubinowski, had this statue "restored and renovated" at his own expense and added a portrait of one of the Polish kings who died in Torun in 1501 and whose heart was buried in that church. Also in the same church, in 1743, Prince Jozef Jablonowski erected another Copernicus statue with the inscription over it in Latin: "To

Nicholas Copernicus, Polish Philosopher and Eternal Ornament of Torun."

Among the private busts of Copernicus in Krakow and in other Polish cities, the one erected in 1823 by the Reverend Father Count Sebastjan Sierakowski, Rector of the University of Krakow, deserves especial consideration. It stands near the high altar in the university church of St. Ann in Krakow. Over it, on the wall, there are two inscriptions. One in Latin: "Nicholas Copernicus, the ornament, the honor and the glory of his country, his city and his university." The other in Polish:

Polskie wydalo go plemie,
Wstrzymal slonce, wzruszyl ziemie.

which, in free translation, means:

"The sun he bade to stop, and at his bidding
the earth began to spin—
Poland has nurtured him."

Because of its brevity and simplicity, this epigram, in the inverted order, became an adage and a property of the entire Polish nation. In the inverted order it reads:

Wstrzymal slonce, wzruszyl ziemie,
Polskie wydalo go plemie.

Up to this time Polish writers on Copernicus have been wondering as to who the author of this apt epigram was. They searched high and low, in fiction and poetry, and finally declared that the author is unknown. They have known, of course, of the uncomplimentary sentiments expressed by Philipp Melanchthon in his full sentence; but this Polish epigram is so *Polish* that it did not occur to them that anybody but a Pole could be its original author. Great truths, simply

expressed, whether intentionally or unintentionally, have a way of crossing national boundaries and of working their way even into sanctuaries.

It is one of the ironies of *Copernicana* that the original author of this Polish epigram was a German, Philipp Melanchthon; a German and a Protestant, the kernel of whose sentiments unwittingly expressed was translated from Latin into the Polish, by a prince of Polish learning and a Polish Roman Catholic churchman (Reverend Father Rector, Count Sebastjan Sierakowski), and inscribed near the high altar in the university church at Krakow. *Sarmaticus Astronomus* (literally, Sarmatian astronomer), was freely and poetically translated into *Polskie wydalo go plemie* (literally, the Polish race has nurtured him); and the rest of Melanchthon's sentence, *qui movet terram et figit Solem* (literally, who is trying to move the earth and stop the sun), was put in the past tense and given a literal translation. Great scientific truth, poetically expressed; that is exactly what Copernicus did in his heliocentric system, he stopped the sun and set the earth in motion.

Medals

There were also numerous medals struck in commemoration of Copernicus—many in Poland, some in other countries. Among the first medals of the early XVIII century, there was one struck by Christian Wermuth of Gotha (Germany), a court medalist. Judging by the inscription on the reverse side, it is not certain whether the court medalist wanted to honor or to ridicule the astronomer. The inscription reads, in German: "According to opinion of the learned, it is the sun and not the earth that turns round. Everybody has his worm, Copernicus has his."

In 1818 a Parisian medalist, Durand, decided to honor, each through a separate medal, one hundred great men of all

nations. Among the first twenty-five were two Poles: Tadeusz Kosciuszko and Nicholas Copernicus. The first Durand medal of Copernicus met with a mishap. It bore the inscription: *Natus Torunii in Prussia.* When somebody called Durand's attention to the fact that this reference to the name of the place of birth might lead to misleading conclusion as to the nationality of the astronomer, Durand brought out a new edition with the inscription: *Natus Torunii in Polonia.* Other French medalists afterwards followed this "corrected edition" of Durand's.

Public Monuments

All the above tributes were private or strictly local and institutional. The first public monument erected in Poland to honor Copernicus, which was at the same time the very first public monument erected in the capital of Poland by popular subscription, was the one unveiled in Warsaw in 1830.

Just as Copernicus belongs to all mankind, even so this first public monument to him is a product of at least three nationalities: Italo-French, Danish and Polish. Curiously it was Napoleon who gave the idea, the Poles gave the money and put their hearts into it, and the well known Danish sculptor—Bertel Thorwaldsen (1770-1844) the son of an Icelander —shaped the idea and the Polish desires into permanent form.

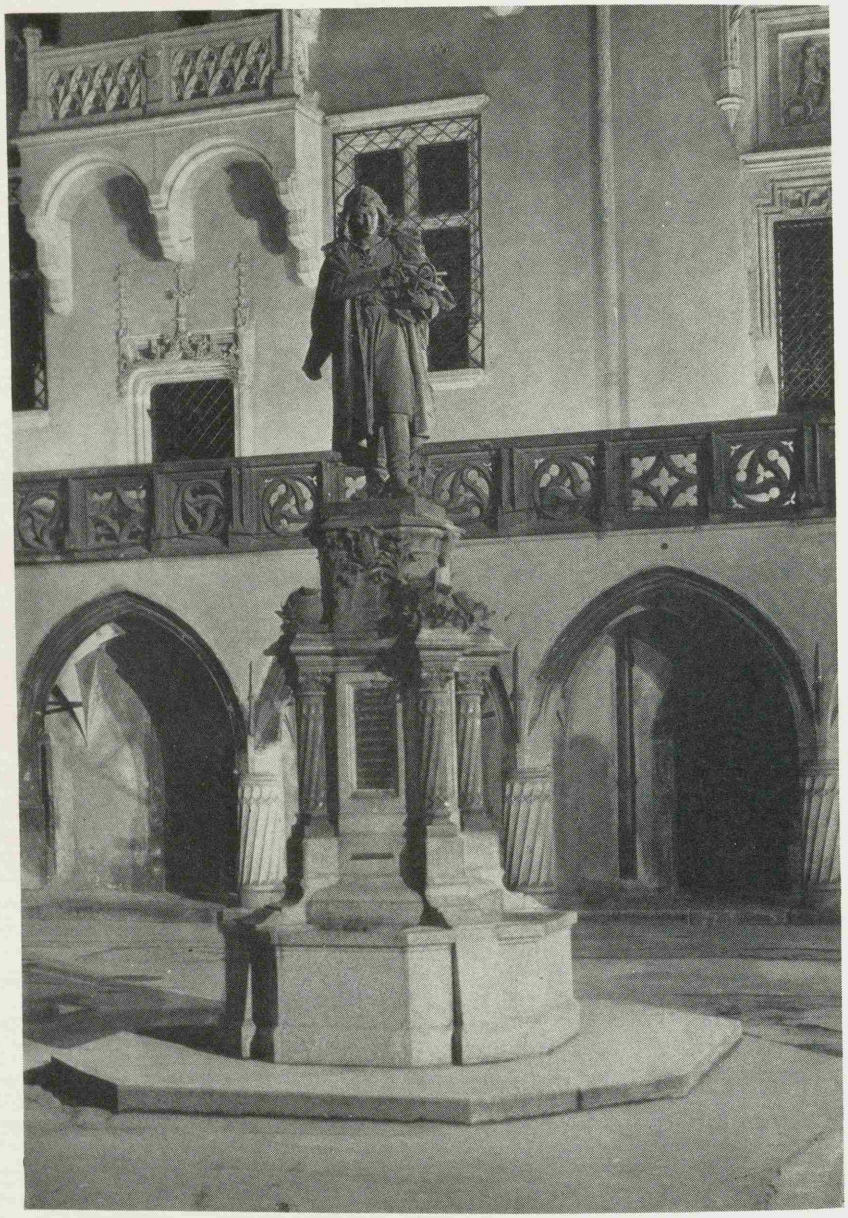
When Napoleon was in Torun in 1807, he expressed surprise that the fellow countrymen of Copernicus had not so far seen fit to honor this great astronomer by a suitable monument in the town of his birth. Acting upon Napoleon's suggestion, in 1809 a group of Warsaw citizens, headed by Stanislaw Staszic, started to raise funds by public subscription for such a monument in Torun, which was then included in the Grand Duchy of Warsaw. For a while in 1809, due to Napoleonic war operations, the State Council transferred its sessions from War-

The house in which Nicholas Copernicus was born—visited by Napoleon. "When Napoleon was in Torun in 1807, he expressed surprise that the fellow countrymen of Copernicus had not so far seen fit to honor this great astronomer by a suitable monument in the town of his birth."

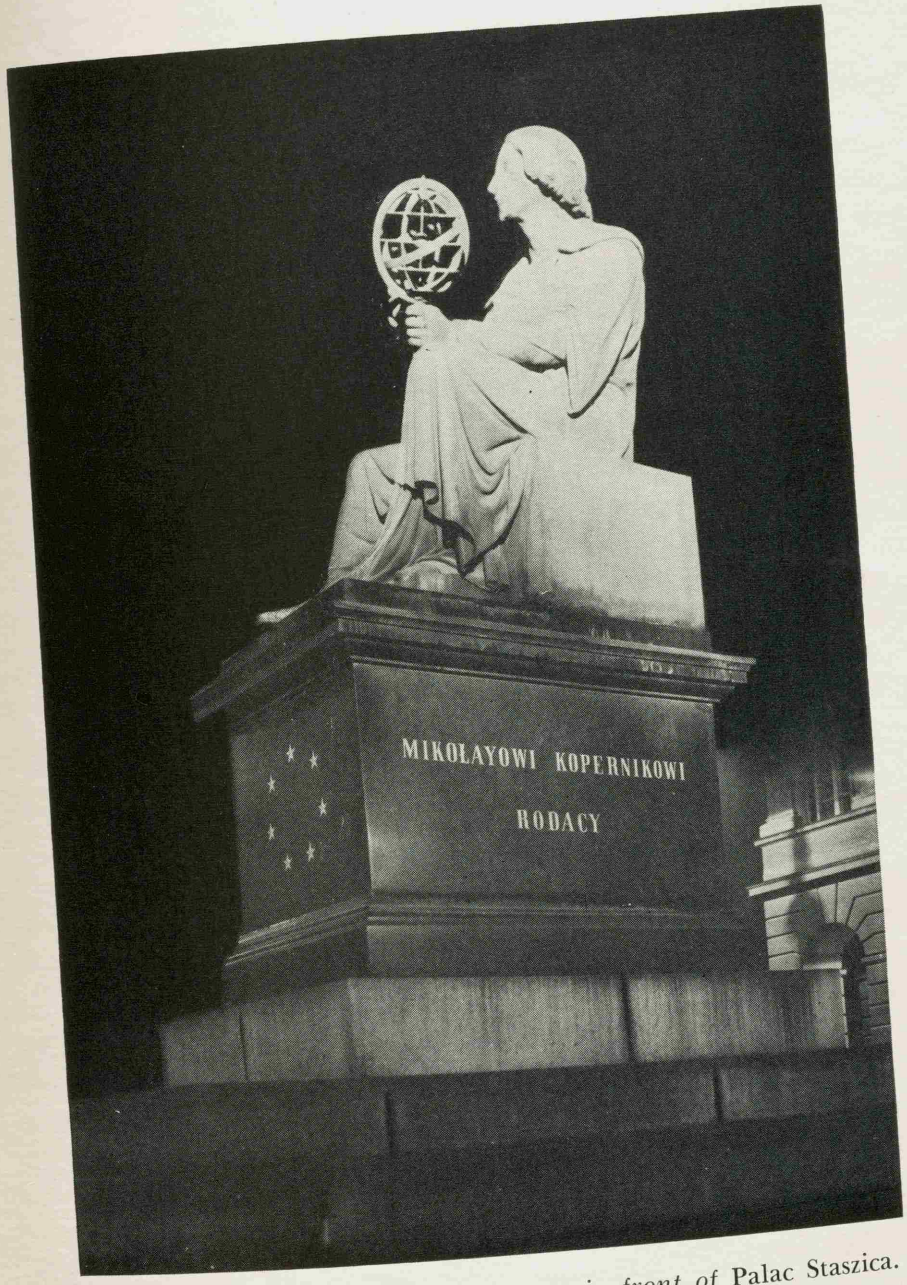
saw to Torun. Thus Torun became a temporary or quasi capital of the Grand Duchy. The State Council voted an initial sum of money, the cornerstone was laid with impressive ceremonies, and for the balance of funds needed to erect the monument an appeal was made to the public. Although 4,795 Polish zlotys were raised, the turmoil of the period interfered with the completion of the project. When, after the Congress of Vienna (1815), Torun was annexed again to German Prussia, the project was not renewed till 1828. Again Stanislaw Staszic, one of the thirty *Great Men and Women of Poland,* revived the movement by a personal donation of 4,000 Polish zlotys and the monument was unveiled in Warsaw on May 11, 1830, in front of the monumental building devoted to science and learning and which, due to other reasons, bears the name of Staszic—*Palac Staszica.*

The monument bears two inscriptions: one in Latin, *Nicolao Copernico Grata Patria* (to Nicholas Copernicus, Grateful Motherland); the other in Polish: *Mikolajowi Kopernikowi, Rodacy* (to Nicholas Copernicus, His Fellow Countrymen). Later on, in 1900, another monument was erected by the University of Krakow in the courtyard of the university library, sculptured by Cyprian Godebski (1835-1909), who also sculptured the Mickiewicz monument in Warsaw. What has happened to the Copernicus monument in the courtyard of the University of Krakow library, we do not know, for entrance into that courtyard is *verboten* to the Poles. But we do know from Polish refugees who escaped from Warsaw in 1940 that one of the things the Germans did when they occupied Warsaw in September, 1939, was to blot out both inscriptions on the Copernicus monument and to substitute for them one of their own: "To Nicholas Copernicus, the German Nation."[15]

This manifestation of the Poles in 1828-30 was a signal for the methodical Germans to start building one of their own in



The Copernicus monument in the courtyard of the University of Krakow library—the identical university building in which Copernicus studied.



The Copernicus monument in Warsaw, in front of Palac Staszica.

Torun, or rather to finish what the Poles had begun in 1809, as a demonstrable and demonstrative reminder to the Poles that Torun and its inhabitants, great and small, have always been and will always be German. Out of the estimated cost of 10,449 thaler, the King of Prussia gave 3,466 or approximately one-third; the German residents of Torun raised 482 thaler; and the practical City Council, which was planning to build a public well in the city square, anyway, added 654 thaler on the condition, which was carried out, that a well be also incorporated in the monument.

Why Are the Poles Proud of Copernicus?

They are proud of him, because the whole civilized world claims him as its own; because the man, his interests and his contributions have universal and abiding qualities. Even the common folk, who may not understand his heliocentric system, instinctively feel that through Copernicus they are bound with other nations by spiritual links that have permanent value.

Although Copernicus lived in an age when there was no clear-cut conception of nationality in the modern sense and loyalties and patriotism — in contradistinction to universal intellectual interests—were chiefly local, they are proud of him also for national patriotic reasons: because he was born and raised on the soil they love and have been shedding their blood to keep free; because he received his first instruction and inspiration in an institution, the University of Krakow, which their beloved Queen Jadwiga endowed with her jewels; because his first great teacher, Albert Brudzewski, has become a part of the great tradition of that ancient seat of learning and cultural center of Poland. Also because he, together with his guardian uncle Bishop Lucas, fought that enemy which

they had been fighting for centuries before and have been fighting all these centuries since: the Knights of the Teutonic Order in all its varied forms. They have a feeling of common heritage and spiritual unity with Copernicus.

A Voice from England Across the Century

After the unsuccessful Insurrection of 1831 a refugee Polish scholar, Col. Lach Szyrma, Professor of the University of Warsaw, found his way to England. In time he mastered the English language and in 1843, on the occasion of the Copernican Tercentenary, delivered in London an impressive lecture on *Copernicus and His Native Land* to the Literary Association of the Friends of Poland.

In the audience there was a Dr. Worthington. So impressed and moved was he by Professor Szyrma's lecture that he improvised a poem as a tribute to the lecturer, to Copernicus and to Poland, and which he delivered immediately after the lecture. The poem was later printed in the *Foreign and Colonial Quarterly Review* (1844, p. 35), also in a pamphlet form.

The present Polish situation is similar to that of 1843. The "earthly empire" of the Polish people "ceased" temporarily; there are even more Polish refugee scholars—from the University of Warsaw and from other universities—both in England and in America; but the Anglo-American association with Poland now has more significant implications than the former *literary association* would seem to indicate. It is therefore eminently fitting and proper that we finish *our* story of *Copernicus and his native land* with Dr. Worthington's *Impromptu*—through courtesy of the Library of Congress:

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If earthly empire with thy people cease,
In one thing, Szyrma, thou mayest yet find peace;
The glorious thought, that in their glowing souls
Lives empire ever 'mid thy deep-wronged Poles;
And if to them the earth be now denied,
Think on it, Szyrma, think with honest pride,
That while the planets circle round the sun,
The race of Polish glory is unrun.
Enthroned with Newton in the starry spheres,
Copernicus unfolds to listening ears
The wondrous laws which Nature bared to him:
And but for him to Newton e'en were dim.
Thus Polish glory blends with God's own might,
And lives in regions of eternal light.

FOOTNOTE REFERENCES

[1] Simon Newcomb (1835-1909), *The Problems of Astronomy,* Report of the Smithsonian Institution for 1896, p. 83.

[2] Nicolaus is the given name most frequently used in the Latinized form. Often a French version, Nicolas, is used as it may also represent a simplified Latin form. For the sake of simplicity and convenience, we shall use the English form, Nicholas, for the given name; and for the surname, the Latinized form of Copernicus, by which he is best known.

[3] The University of Krakow was established in 1364 by the last king of the Polish Piast dynasty, Casimir the Great; it was reorganized and renovated in the year 1400 by King Jagiello, in deference to the wish of Queen Jadwiga (d.1399) who sold her jewels and directed that part of the proceeds be used for the benefit of that university. The balance of the proceeds was distributed to the poor. It is the second oldest university in central Europe and one of the oldest on the continent. Preceding it were: Bologna (end of XII century), Padua (1222), Paris (between 1150 and 1170), Prague (1347), Oxford (end of XII century) and Cambridge (beginning of XIII century). All German universities were organized later: Heidelberg, the oldest, in 1385; Cologne, in 1388; Leipzig, in 1409.

[4] That the University of Krakow, especially its Faculty of Astronomy and Mathematics, was well thought of in other lands, is attested—among others—by a contemporary German writer, Hartman Schedelius. In his *Chronicle of the World* he writes: "Near the Church of St. Ann there is a university, famous for its many great and learned men, where all kinds of arts and sciences are cultivated. Foremost among them is astronomy. In this respect, as I am informed by many people, there is not a single school that is more famous in all the lands of the Germans."

Liber Chronic., Norimb. 1493, fol. 266.

[5] Marcin Bylica, the most outstanding Polish astronomer before Albert Brudzewski, was a former student at the University of Krakow and later a member of its teaching staff. He also lectured on astronomy at the University of Bologna; later became professor of astronomy at the newly-founded university (of temporary existence) at Pressburg (Bratislava), then under Hungary, and at Buda. Bylica was one of the first alumni benefactors of his *Alma Mater Cracoviensis.*

[6] The office of canon, although a part of the Church hierarchy, did not require that its incumbent be a fully ordained priest. Despite the earlier assertions of some Polish writers on Copernicus, later occasionally echoed by other writers, Copernicus was not a priest in the full sense of the word; a churchman, but not a priest.

[7] In 1908 there was discovered in the State Archives of Sweden at Stockholm, a most interesting document that throws additional light on Copernicus's active part in contemporary political events. It was a complaint against the predatory inroads of the Teutonic Order and a petition addressed to Sigismund I, King of Poland, asking for help. Dated July 22, 1516, the petition was drawn in Copernicus's own handwriting, in Latin, in behalf of the Chancery of the Bishopric of Varmia. Apparently clean copy was made and dispatched to the king and this original draft remained in Copernicus's own library, which was carried to Sweden by Gustavus Adolphus in 1626.

After a documented complaint, mentioning names and places, Copernicus calls these Knights of the Teutonic Order *latrones* (robbers), and on behalf of his colleagues concludes as follows:

"We are offering our loyal services and even our very lives, to your Majesty whom we regard as our most gracious Lord" *(offerentes fidelia servitia nostra et ipsam vitam nostram eidem Maiestati Vestre, quam ut Dominum nostrum clementissimum colimus.)*

[8] *Der Narr will die ganze Kunst Astronomiæ umkehren.* Martin Luther's *Tischreden,* vol. IV, p. 575.

[9] Philipi Melanchtonis *Opera,* ed. Carolus Gottlieb Bretschneider, 1837, *Corpus Reformatorum* vol. IV p. 679. (See photographic reproduction of the page referred to).

Another German, sometimes even called "the Great," Frederick II (1712-1786), King of Prussia, in writing to Voltaire (Dec. 11, 1773) as one cynic to another after the first partition of Poland which he "rescued" from all kinds of tyranny, referred to it as "the country which produced Copernicus"—*un pays qui avait produit un Copernic (Oeuvres Posthumes de Frederic II Roi de Prussie,* Berlin ed. 1788, vol. IX p. 208). Even sixty years later a celebrated German historian of literature, Johann Ludwig Wachler (in his monumental *Geschichte der Literatur,* 1833, vol. IV, p. 263), wrote: "Among other nations [which have great sons to be proud of] Poland has a full right to be proud of her Nicholas Copernicus of Torun" *(mit vollem Recht stoltz auf ihren Nicolaus Copernicus aus Thorn).* Even several decades later, Friedrich Wilhelm Nietzsche (1844-1900), the noted German philosopher, paid a tribute to Copernicus as a Pole by saying: ". . . he (Boscovich) and the Pole Copernicus have hitherto been the greatest and most successful opponents of ocular evidence." [Roger Joseph Boscovich (1711?-1787) was an eminent Serbo-Croat scientist.] The *Authorized English Translations of Nietzsche's Works,* by Oscar Levy, New York, 1909-13, 18 vols. vol. XII *Beyond Good and Evil,* p. 19.

[10] Dambraw, the root word for Dabrowski, in later Polish orthography was spelled Dabrowa.

[11] The ponderous German scholarship, in trying to evolve German nationality out of the name of Copernicus, leaned heavily on Slavonic philology through the reasoning that his ancestors' name was spelled with a double "p." As the name with a double "p" could not be Polish, they argued, it must have therefore been German.

Now, there are two difficulties with the conclusion of this reasoning. First, that the family name of Kopernik—Koppirnig or even Koppernigk—was derived from the name of the village and not the other way round. Even if the name of the village is of German origin, it does not follow that all its former inhabitants, surnamed after the place of their former domicile, were necessarily German. Secondly, that we have numerous instances of indisputably Polish historic names misspelled beyond recognition. Thus Bernard Wapowski (as Polish as Paderewski), a life-long friend of Copernicus, had his name spelled even by his Polish contemporaries in such ways as Vapouskij, Vapovskij, Vapovsski, Vapovsky, and Vapovssky. Through philological reasoning one could make out any nationality from one of these variants, any nationality but Polish.

[12] Katherine Modlibog was previously married to a Pek or Penk.

[13] Besides Barbara, the mother of our astronomer, the Watzelrod's had one o possibly two other daughters. One of them married a Maciej Konopacki, Chamber lain of Chelmno. One of the Konopacki's daughters, in turn, married a Sebastja Czapski. The male descendants of the Czapski's (i.e. collateral descendants of Nicho las Copernicus), have played prominent roles in Polish history as statesmen, soldie and philanthropists up to the present time. One of them, Count Emeryk Czapsk (1828-96), founded a museum bearing his name and bequeathed it, together with

rich numismatic collection, to the city of Krakow. The widow of his elder son, Count Karol Jan Aleksander Czapski (1860-1904), is now a refugee in New York and at this writing happens to be a neighbor of the present writer.

[14] The later re-Polonization process from Thorn was: Thorunia, Thorun, Torun. There is difference of opinion among historians as to the exact name of the original Polish settlement on which Torun was built. At least one writer on Copernicus credits the first Polish historian, Jan Dlugosz (1415-1480), with having mentioned "Torun on the Vistula" in connection with historical events of 1192. Upon checking up on the original Latin text of Dlugosz, the present writer discovered that Dlugosz had his geography mixed up, placed another town on the Vistula where it did not belong, did not mention Torun at all, and only a later editor of Dlugosz's works put Torun in the footnote—thinking that the historian had this town on the Vistula in mind.

[15] A very careful search failed to reveal a single monument in honor of Copernicus either in Berlin or in any other German city.

Bibliographical Suggestions and Comments

The literature on the subject of Nicholas Copernicus is very extensive—running, literally, into thousands of volumes, special articles, monographs, chapters in histories of astronomy, in biographies of scientists etc.; but its value is strikingly unequal and there is not a single definitive, up-to-date, objective biography in any language—not even in Polish.

The most comprehensive single work up to 1884 and still useful on the bibliographical information, that of Dr. Leopold Prowe, has this shortcoming that it is warped by polemics in favor of his pet theory that Copernicus was a Teuton. Also has many errors in the scientific phases.

The greatest Copernican scholar so far has been the late Ludwik A. Birkenmajer (d. 1929), professor at the University of Krakow, who had written several volumes—a few of which are of monumental import and proportions—and dozens of monographic contributions. Unfortunately: (1) he wrote most of his best works in Polish and therefore they are inaccessible to foreign scholars; (2) his definitive biography of Copernicus, giving a synthesis of all his lifetime researches, has not been published and reposes (or reposed till 1939) in the manuscript form at the University of Krakow library; (3) his only attempt at synthesis was a popular book of 126 pages written on demand in 1923 (*Mikolaj Kopernik, Jako Uczony, Tworca i Obywatel.* Krakow, The Polish Academy, 1923) and is quite inadequate as a single work.

Most of our current biographical sketches available to the average American reader show confusion and give, with solid information, plenty of misinformation. One important American encyclopaedia, for example, puts Torun in Poland, but makes Copernicus study medicine in Krakow (which is not true) and places the well-known Thorwaldsen monument of

Copernicus in Krakow instead of Warsaw. Another important encyclopaedia refers to Copernicus as "a celebrated Polish astronomer, born at Thorn, a Prussian [?] town on the Vistula, at that time belonging to Poland." And then informs the reader that Copernicus "was instructed in the Latin and Greek languages at home." Perhaps its does not matter much, but the fact is that Copernicus began to study his Greek only ? an university student in Italy—possibly already at Bologna, and definitely at Padua in 1501-03. The only recent book in the English language devoted exclusively to Copernicus and which makes an attempt at synthesis (Angus Armitage, *Copernicus—The Founder of Modern Astronomy*) relied so "principally" (as the author admits) on Dr. Prowe in biographical data as to state even that Krakow "was founded by Germans" (p. 44). It may be strange but among the short encyclopaedic articles, one of the very best is in *Enciclopedia Italiana* on *Nicolo Copernico* by Guido H. D'Arturo, Professor of Astronomy at the University of Bologna. A well-balanced bibliography accompanies the article.

The following selected list of reading references, with such comments as may seem justified, will be helpful to a reader who may want more information of a general nature on the subject of Copernicus and his life and work, and on the Ptolemaic and Copernican systems of astronomy.

In English

1. *Encyclopaedia Britannica.* Copernicus, Astronomy (History of Astronomy), and Index references to Copernicus, his predecessors and successors.

2. *Great Men and Women of Poland.* Edited by Stephen P. Mizwa, The Macmillan Company, New York, 1941, pp. 397. Chapter on Nicholas Copernicus with illustration, pp. 37-50, by a Polish scholar who for the time being remains anonymous.

3. Ernest R. Trattner, *The Story of the World's Great Thinkers,* The New Home Library, New York, 1938, pp. 426. The first chapter, pp. 11-45, is on Nicholas Copernicus.

Despite its numerous errors, resulting from attempts at emphasis and oversimplification, this chapter is a very good popular introduction to a better understanding of the Ptolemaic and Copernican systems of the universe.

4. Dorothy Stimson, Ph.D., *The Gradual Acceptance of the Copernican Theory of the Universe,* a doctoral dissertation, New York, 1917, pp. 147. No longer carried by trade selling agents but copies can still be obtained at $1.50 each from: Dean Dorothy Stimson, Goucher College, Baltimore, Md.

A fine and thoroughly reliable piece of work, well documented, preceded by a brief historical sketch of the heliocentric theory of the universe.

5. John L. E. Dreyer, *History of the Planetary System from Thales to Kepler,* Cambridge University Press, 1906. Out of print now but can be consulted in libraries.

One of the best in the field of astronomy in general.

6. Angus Armitage, *Copernicus—The Founder of Modern Astronomy,* George Allen and Unwin, London, 1938, pp. 183.

More useful to students of astronomy than to the general reader. Except for a brief French summary of one of Birkenmajer's works, the author was thoroughly unfamiliar with the research work of Polish Copernican scholars.

7. Edward Rosen (translator), *Three Copernican Treatises* (The Commentariolus of Copernicus, The Letter Against Werner, The Narratio Prima of Rheticus), Columbia University Press, New York, 1939.

Translation of the original texts.

8. Arthur Berry, *A Short History of Astronomy,* New York, 1910.

9. A. Wolf, *A History of Science, Technology, and Philosophy in the 16th and 17th Centuries,* New York, 1935.

In Polish

1. Ks. Ignacy Polkowski, *Zywot Mikolaja Kopernika* (The Life-Story of Nicholas Copernicus), Gniezno, 1873, pp. 356.

   The first good biography of Copernicus in the Polish language, well documented. Though superseded by works with more discriminating evaluation of sources, it is still very useful. However, very few copies are available in America.

2. Ks. Ignacy Polkowski (compiler), *Kopernikijana czyli materjaly do pism i zycia Mikolaja Kopernika* (Copernicana or materials on the writings and life of Nicholas Copernicus), Gniezno, 1873-75, 3 vols.

   Valuable Copernicana materials in Polish.

3. Ludwik A. Birkenmajer, *Mikolaj Kopernik—Studya nad Pracami Kopernika oraz Materyaly Biograficzne, Czesc I* (Nicholas Copernicus – Studies on the Writings of Copernicus and Biographical Materials, Part I), The Polish Academy of Sciences, Krakow, 1900, pp. 711, *quarto*.

   A monumental piece of work, in which the author gives some of the preliminary results of his research on the genesis and development of the Copernican heliocentric system. Part II, which was to give a definitive biography of Copernicus, was not published. The manuscript was deposited in the University of Krakow library.

4. Ludwik A. Birkenmajer, *Mikolaj Kopernik—Jako Uczony, Tworca i Obywatel* (Nicholas Copernicus—as a Scientist, Scientific Creator and Citizen), The Polish Academy of Sciences, Krakow, 1923, pp. 126.

   A popular monograph of this great Copernican scholar. Not as valuable to scholars as some of the other scientific monographs.

5. Ludwik A. Birkenmajer, *Stromata Copernica,* Krakow, 1924.

   A continuation of the Polish Academy publication of 1900.

6. *Mikolaj Kopernik, Lwowski Komitet Obchodu 450 Rocznicy Urodzin M. Kopernika* (Nicholas Copernicus, published by the Lwow

Committee Commemorating the 450th Anniversary of the Birth of N. Copernicus), Lwow, 1924, pp. 246.

Includes ten commemorative essays dealing with various aspects of the great astonomer's work. Of unequal length and value. Among the outstanding are: Prof. Fr. Bujak's essay on *Copernicus's Treatise on Money* and a *Copernicana Bibliography* prepared by W. Bruchnalski. The selected bibliography, covering the period 1543-1923 and limited for the most part to Polish works, is well annotated and consists of 588 items.

7. Jeremi Wasiutynski, *Kopernik: Tworca Nowego Nieba* (Copernicus: The Creator of the New Heavens), pub. J. Przeworski, Warsaw, 1938, pp. 666.

A remarkable performance of a young man, who attempted to write a definitive biography of Copernicus with the aid of the new sociologico-psychological tools. The subject is perhaps overpsychoanalyzed. In trying to reach different conclusions from previous Copernican scholars, the author is often rasping. Reads like an historical novel, although its scientific value, for the most part, is much greater. Taken in conjunction with other works as correctives, it will have a permanent place in the Polish literature on the subject.

8. Zygmunt Batowski, *Wizerunki Kopernika* (Portraits of Copernicus), Torun, 1933, pp. 99.

Contains 18 illustrations with descriptive and historical sketches. Very good as far as it goes.

Part III

PROGRAM SUGGESTIONS

AS THIS BROCHURE went to press (December 1, 1942), the Kosciuszko Foundation, which initiated the Copernican Quadricentennial, was already in possession of several hundred letters from heads of American colleges and universities, of junior and state teachers colleges as well as of leading higher institutions of learning in Canada,—all enthusiastically endorsing the project of the Copernican Quadricentennial and expressing a desire to join the Kosciuszko Foundation in arranging in each case some appropriate celebration or tribute to Copernicus on this important anniversary. It was also evident that there will be citizens committees in hundreds of communities scattered throughout the United States that will arrange such celebrations either jointly with local colleges and universities or as separate community projects.

On the occasion of the Copernican Quadricentennial, the Polish Institute of Arts and Sciences in New York, as one of its cooperative contributions, is planning: First, to arrange a series of lectures by outstanding scholars, on Copernicus and Poland in the Copernican Era. Second, to publish a symposium of monographs on Life and Work of Copernicus. Polish scholars of the University of Krakow, in conjunction with the Polish Academy, were planning, on the occasion of the Copernican Quadricentennial in 1943, to bring out an edition of complete works of Copernicus, *Opera Omnia*, incorporating the latest results of scientific research. The war interfered and this symposium of Polish scholars in America

will be a modest expression of the formerly more ambitious plan.

Because most of the colleges and universities now operate under the accelerated war program, with the current school year ending early in May, a good many heads of these institutions asked us if they could hold their Copernican programs earlier in May or after May 24th. The answer, of course, is Yes. We are celebrating not so much the death of the great astronomer as the publication of his immortal work, *De Revolutionibus Orbium Coelestium,* and the birth of modern science of astronomy, of modern science in general. The 400th anniversary of the death of Copernicus is only a prompting occasion.

Invariably these expressions of desire to join in this national tribute to Copernicus were accompanied by requests for more information about the subject, for program suggestions, sometimes even for recommendations of speakers. Occasionally an observation was made that, due to the crowded calendar, only a chapel period could be devoted to the Copernican program—with one short address on Copernicus and some reference to other Poles and their contributions to civilization.

We are therefore suggesting two alternative programs: a short program suitable for a chapel period, not lasting more than thirty minutes; and a full Copernican Quadricentennial Program for an hour and a half to two hours.

I. Short Program

1. "The Broken Note" Signal.
2. The American and Polish National Anthems.
3. *Gaude Mater Polonia.*
4. Address: Nicholas Copernicus.

In case the speaker should like to mention other Poles and their contributions, the most accessible information may be found in a single volume: "Great Men and Women of Poland" edited by the present writer and published by The Macmillan Company, New York, 1942.

The full program as outlined, if time permits, can be easily arranged by universities, colleges, schools and citizens committees—with such modifications, extensions or simplifications as local conditions warrant or make necessary.

II. The Copernican Quadricentennial Program

1. "The Broken Note" Signal (trumpet).
2. The American and Polish National Anthems.
3. *Gaude Mater Polonia.*
4. Address: Nicholas Copernicus and His Contributions.
5. Short Pageant: The Initiation of Copernicus into the University of Krakow (optional).
6. Address: The Death of Copernicus, and the Birth of Modern Science.
7. Address: The Universality of Science, Its Place in Modern Life and in the World of Tomorrow (optional).
8. The *Alma Mater* song of given college or university, or some patriotic hymn of universal appeal in which the audience may join (e.g. "America" or "Star Spangled Banner").
9. *Copernicana* Exhibit.

Explanations

(1) "The Broken Note" Signal.

In the main square of the ancient city of Krakow stands St. Mary's Church, from one of whose towers a trumpeter plays a signal, known as the *hejnal,* every hour on the hour of day and of night.

The tradition of this "Trumpeter of Krakow" — made known to America by Prof. Eric P. Kelly through his book under that title, the Newbury Medal winner for 1928—goes back to days long before Copernicus, to the days of the great Tartar invasion of Poland in the year 1241. The function of the trumpeter was to give a signal when he saw an approaching foe and thus warn the inhabitants of Krakow. One day, as the Tartars were approaching the city square, the trumpeter gave the signal. Before he finished it, a Tartar arrow pierced his throat. Hence, the broken note, the unfinished melody. That's the traditional basis of the "broken note" *hejnal.* Historically, it was introduced as a permanent institution by Louis the Great, King of Hungary, who was also the absentee ruler of Poland (1370-82) the father of Jadwiga Queen of Poland (1384-99). In Polish *hejnal,* it most probably comes from the Hungarian *hajnal,* meaning the morning star—planet Venus—dawn, daybreak, hence figuratively the *reveille.*

When the Germans occupied Krakow in September, 1939, they silenced the trumpeter in Krakow, but his melody lingers on. There are echoes of it in America. At Vassar College, for example, the broken note *hejnal* is played as a call to chapel. This old melody with rich historic associations seems to us to be most appropriate as an opening note for any Copernican program.

(2) The National Anthems may be played by an orchestra or sung by a choir or the audience.

(3) *Gaude Mater Polonia.* Sung in Krakow in the student

days of Copernicus, this is one of the three oldest Polish hymns dating back to the XIII century. It originated as a hymn to St. Stanislaus on the occasion of his canonization in 1253. It was in time adopted by the University of Krakow and was sung on all dignified academic occasions: such as opening and closing of the school year, welcoming distinguished foreign guests, granting of honorary degrees to men of outstanding accomplishments. It is most effective when rendered by a male quartet or chorus, either in unison or in parts, a capella or with instrumental accompaniment, but can also be sung by a women's or a mixed chorus.

The chorus number of *Gaude Mater Polonia* may be obtained in the following versions: for men's chorus, for women's chorus and for mixed chorus, at 10 cents per copy. From:

Boosey, Hawkes, Belwin, Inc.
43 West 23rd Street
New York, N. Y.

The same versions may also be obtained from corresponding houses in the following countries:

In England	295 Regent Street London, W. 1
In Canada	10 Shuter Street Toronto
In Australia	National Building 250 Pitt Street Sydney
In Africa	African Book and Music Dept. Commerce Chambers 84 Loop Street Capetown, S. A.

(4) Address on Nicholas Copernicus. This can be prepared by a local or invited astronomer, mathematician, physicist or anyone interested in the history of civilization in general and in this subject in particular. In a good many cases the information on Copernicus given in this brochure may be sufficient to serve as basis for a popular address, with such additional reading as may be done in local libraries. We are sorry, however, that it would be impossible for the Kosciuszko Foundation to supply speakers.

(5) Short Pageant: The Initiation of Copernicus into the University of Krakow.

We are all familiar with our contemporary student antics in connection with initiation into college fraternities and sororities. The practice is "as old as the hills." There is nothing new that the Polish students at Krakow in the days of Copernicus did not know, or did not put in practice. Only there the initiation of the "greenhorns" at that time was not into any particular fraternity, but into the brotherhood of university scholars in general.

By way of entertainment and especial attraction, those schools, colleges and universities that have dramatic departments may want to prepare a ten or fifteen minute pageant depicting this Polish medieval university custom. Authentic university costumes of both students and tutors are herein reproduced as suggestions for costume designs. Considerable freedom of interpretation may be exercised in the conception and execution of such a pageant.

(6) The Death of Copernicus, and the Birth of Modern Science.

These Copernican programs are intended partly as a commemoration of the death of Copernicus, but mostly as a celebration of the birth of modern science. It would therefore be most fitting, if circumstances warrant, to pay tribute to other

scientists who, together with Copernicus, pioneered the way to modern science.

(7) The Universality of Modern Science.

Copernicus wrote his great work in Latin. Just as Latin was a universal language which all scholars of his day knew and used, science also is universal. It recognizes no political boundaries, pays no attention to nationalities. All contributions became common property of all men. Whether it be Nicholas Copernicus and Marie Sklodowska Curie the Poles, Leonardo da Vinci and Galileo Galilei the Italians, Francis Bacon and William Harvey the Englishmen, Walter Reed and Thomas A. Edison the Americans, Jean Baptiste Lamarck and Louis Pasteur the Frenchmen, Tycho Brahe the Dane, Shibasaburo Kitasato the Japanese, Johann Kepler the German, and Albert Einstein the German Jew—they all belong in the same fraternity of servants and benefactors of mankind. And when the work of destruction is over, that of healing and reconstruction will begin and science (not Polish, Italian, English, Japanese, French, Danish, Jewish or American science, but simply science) will again become the handmaid of civilization.

This spirit of unity and universality of science could most appropriately be emphasized as a part of the tribute to Copernicus.

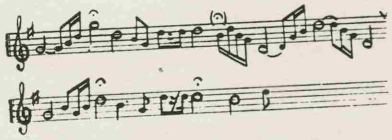
(9) *Copernicana* Exhibits. Yale University, in conjunction with the Copernican program, is planning to arrange an exhibit of all items in possession of the Yale Library pertaining to Copernicus. The New York Public Library will have a similar exhibit — under the title: "Copernicus and His Contemporaries." A number of other institutions and larger libraries, private and public, will arrange *Copernicana* Exhibits.

Since almost every larger library has something on Coper-

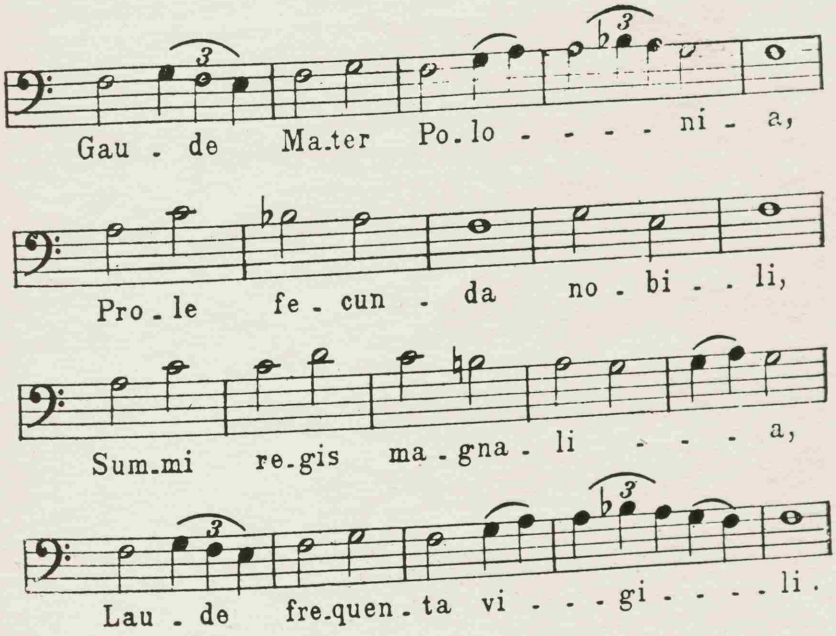
nicus or astronomy, either books or pictures, it is suggested that some exhibits be planned—however modest—for the week commencing Monday, May 24, 1943; or, if this date be inconvenient, arrange them at an earlier or later date.

The Copernican Quadricentennial National Committee

As this brochure goes to press, a National Committee under the above name is being organized with extensive plans for a national celebration in New York, Monday evening, May 24, 1943. A large representation of foreign scholars from many lands is also expected. As the plans crystallize they will be announced through the press.

It is hoped that the proceedings of the main celebration will be published in an appropriate volume or album, which will also list all the institutional and local Copernican Quadricentennial celebrations, tributes, etc., so as to give this important anniversary a permanent record. It is therefore most desirable that every Copernican program, however modest, be reported to the Kosciuszko Foundation so that we can make the record as complete as possible.

(Above) *"The Broken Note" Signal of the "Trumpeter of Krakow."*
No. 1 on the Program.

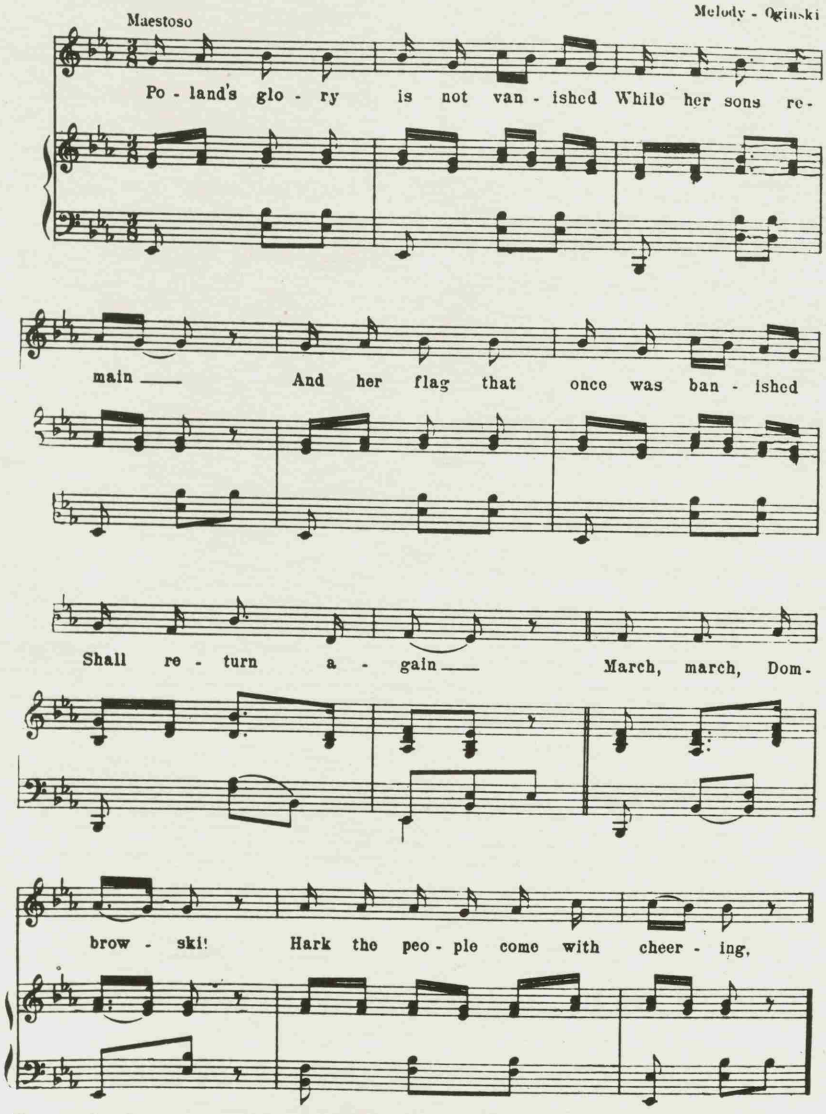
(Below) Gaude Mater Polonia.
No. 3 on the Program.

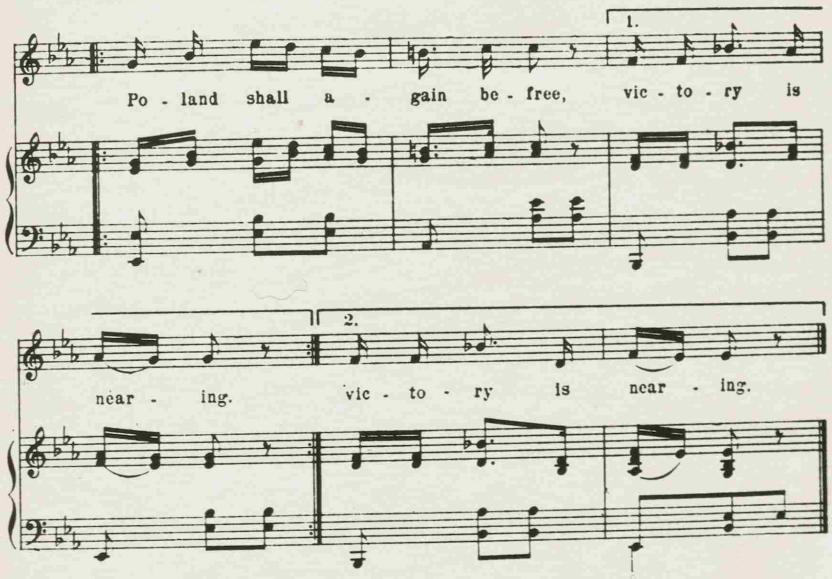


POLISH NATIONAL ANTHEM

English version by
Edwin Markham

Melody - Ogiński



From the Botsford collection of Folk Songs. Copyright 1922 and 1931 by G. Schirmer, Inc. Printed by permission of the publisher and Mrs. Botsford.

Jeszcze Polska nie zginęła

Jeszcze Polska nie zginęła,
Kiedy my żyjemy;
Co nam obca przemoc wzięła,
Mocą odbierzemy.
Marsz, marsz, Dąbrowski,
Z ziemi włoskiej do polskiej.
Za twoim przewodem,
Złączym się z narodem.

Choć sąsiady nas zniszczyły,
I broń nam zabrały,
Sparty piersi murem były
I te nam zostały.
Marsz, marsz, Dąbrowski,
Z ziemi włoskiej do polskiej,
Każdy z nas chęć czuje,
Wodza nie brakuje.

Dzielność wolnego oręża,
Starzec opowiada,
Aby szukać tego męża
Młody na koń siada.
Marsz, marsz, Dąbrowski,
Z ziemi włoskiej do polskiej,
Wolność, dawne hasło
Jeszcze w nas nie zgasło.

Polish National Anthem

Poland's glory is not vanished
While her sons remain.
And her flag that once was banished
Shall return again.

Refrain
March, march, Dombrowski!
Hark the people come with cheering,
Poland shall again be free, victory is nearing.

Poland's wrongs shall all be righted,
Youth of Poland call.
Freedom's torch we bring uplighted,
Spartan breasts our wall.

Refrain – March, march etc.

Poland's sons again will muster,
And drive out the foe;
Will bring back her ancient lustre,
Bring her joy for woe.

Refrain – March, march etc.

English version by
Edwin Markham

Plate I

How Polish Students Dressed in the Student Days of Copernicus (1491-95)

In those days universities were in the service of the church. Professors were generally churchmen; and students, for the most part, were preparing themselves for the church. Hence, they all dressed modestly and their costumes resembled those of priests and monks. Sombre colors—black, dark blue and gray —predominated (see Plate I on p. 76).

But, as in our own days, there were rich and poor students, the serious and the frivolous. Copernicus undoubtedly belonged in the serious group. Although modest (long and sombre dress) was prescribed for all, the rich and the frivolous were often guilty of breach of discipline. Already in the last decade of the XV century there was at the University of Krakow a rebellion against the traditional dress. Such boys as were full of "college spirit" began to wear "indecent" (vestis indecens) *clothes: short, tight-fitting and hilariously gaudy (see Plate II on p. 78).*

Plate II shows a violent reaction against the prescribed dress, under the influence of Italian universities from which Polish students were returning in increasing numbers. All sorts of brilliant color combinations began to appear, such as: navy and sapphire-blue, yellow, red, cherry-red, even slippers were red or blue. Each student tried to exercise his ingenuity by having a different color combination from the rest. Fourth from left, for example, is the dandy, with puffed sleeves and striped (light-blue and black) breeches. A typical color combination may be in number one: sapphire-blue jacket, yellow sleeves, cherry-red velvet sleeve cuffs, cherry-red beret with gray feather, cherry-red slippers with gray fur trimmings. In other cases colors were differently combined.

When it came to initiation of "greenhorns" (only they were called beani—*"yellow beaks") and to hazing, the frivolous perhaps dominated the scene.*

Plate II

Part IV

IN THE NAME OF COPERNICUS

Is Poland to Be a "Cultural Wilderness"?

On the occasion of the Copernican Quadricentennial, the Kosciuszko Foundation will commence its preliminary and preparatory work looking forward towards the post-war educational reconstruction of Poland. Thus the commemoration of a great Polish scientist of the distant past may become a call to the living to pass on a torch of light to those of the future.

When the Germans came to Poland in 1939, those *Kulturtraeger* ("carriers of culture") announced that they would make a "cultural wilderness" — *ein Kulturwueste* — out of the land they conquered. And they are doing it with relentless efficiency. All the universities and all secondary schools, with the exception of some trade schools, have been closed. The reason given: "A slave nation needs no higher education" and can therefore dispense with such luxury. Scientific laboratories, museums and university libraries have been looted; hundreds of university professors have been thrown into concentration camps; scores of them died in these camps, scores of others died after release and before the firing squad. Of the 200 members of various Faculties of the University of Krakow alone, the Alma Mater of Copernicus, twenty-nine are definitely know to be dead—fourteen in the concentration camp.

The University of Copernicus, including its Department

of Astronomy, suffered the most. Towards the end of October, 1939, the occupational authorities informed the Rector of the university to open the university as usual and to call all faculty members for this ceremony, the special feature of which was to be a lecture by a German scientist on the policy of National Socialism towards universities. When in the morning of November 6th they all assembled in the university hall, which is graced by the original painting of Copernicus by the national painter of Poland, Jan Matejko, the Gestapo surrounded the building and a Dr. Meyer of the Gestapo appeared on the lecture platform with the following announcement: "As you all understand German, it will not be necessary for me to have my address translated into the Polish. Because you tried to open the university without our knowledge and consent, because you carried on your laboratory work and conducted examinations without our approval, and, finally, because this university of yours has always been a bastion of what you call Polish culture,—you are all under arrest." Then the doors flung open, 170 members of the faculty (including professors emeriti, some old and feeble) were thrown into lorries and carried off to unknown destination. Within a few weeks urns with ashes began to arrive; early in February, 1940, 105 living skeletons arrived in Krakow—many of whom did not linger long—and the rest are still paying for the crime of having been connected with that "bastion of what the Poles call Polish culture."

History will pass its judgment and the mills of gods in due time will grind out their own measure of justice.

In the meanwhile, it would be comforting to those Polish scholars and scientists who are still alive to know that, on the occasion of the Copernican Quadricentennial, we have decided to help them or their successors in the rebuilding of their workshops that have been destroyed or despoiled.

Best American Books as Nucleus

Even while this second World War is still raging and nobody knows when it is going to end, governments, institutions and individuals are already making plans for the post-war period of reconstruction. Complete blueprints with all details could not be drawn now, yet certain problems are already apparent and plans can be made ahead of time looking forward to their solution.

Four things are certain:

1. That there will be a United States of America, playing a leading role in the future scheme of things and in inter-continental affairs.

2. That such Poles as shall have survived, whether professors or students, teachers or pupils, will try under new conditions—whatever they may be—to reorganize their teaching facilities and to teach or prepare themselves for such tasks of construction and reconstruction as they will be facing in the future.

3. That the new Poland will have to start from scratch so far as higher educational facilities in general are concerned, and libraries in particular. Most university buildings are still standing, and it is hoped that they will be standing, but they have been despoiled of equipment and libraries have been looted. Such book collections as have not been destroyed will be disgorged and in time will be restored to Poland; but in the meanwhile, professors and students of the restored New Poland will need basic books, especially such as will contain progress made in America during the period when Polish science and learning were blacked out, so that they can start their work immediately.

4. That the scholars of the New Poland will be looking to America for such help in this respect as may be possible for us to give them.

One of the best services we can render on behalf of America to the reconstruction of higher education in Poland will be along lines of helping the Polish higher institutions of learning to establish nuclei of their working libraries with basic books published in America in various fields. A collection of from 5,000 to 10,000 well chosen titles, with several duplicates of each volume making a total of from 20,000 to 30,000 volumes, would fill the basic initial needs. Some volumes may be secured as donations from individual American scholars, from library duplicates and from publishers; others will be purchased as funds become available and actual contions call for the final step in the program now undertaken.

The Kosciuszko Foundation has already received enthusiastic expressions of personal interest and assurances of moral support and cooperation of officials of the American Library Association, the Library of Congress and of other institutional representatives to whom the educational needs of the Poland of Tomorrow were incidentally mentioned.

Definite preparatory steps will be taken on the occasion of the Copernican Quadricentennial. As the first token of our future intentions and the practical expression of our good will, the Kosciuszko Foundation is making arrangements to send on this occasion to the Polish Medical Faculty at Edinburgh, Scotland, some of our best medical books and a number of the leading medical journals, published in America. With the definite understanding, however, that after the war these and other books and journals, which may subsequently be shipped, will be transferred to medical schools in Poland.

The preliminary or preparatory work, to which reference was made above, will consist of preparing master indices of the best works in every essential field published in America; where, when, and by whom published; where available when actually needed, and at what price if any.

Two Chairs in American Civilization

As a part of the quadricentennial tribute to Copernicus the Board of Trustees of the Kosciuszko Foundation, at their annual meeting on October 9, 1942, besides approving the above plan, passed a resolution expressing their intention to establish and support, with the cooperation of their friends old and new, two Chairs in American Civilization; one at the University of Krakow, the Alma Mater of Copernicus, and the other in the leading university of the nation's capital.

Filled periodically by American scholars who are recognized authorities in their respective subjects, each Chair will cover such basic fields as American history, constitutional development and political institutions (i.e. democracy in theory and practice), American contributions in the fields of business organization, science, industry and technology; also certain aspects of American culture as expressed in art, architecture, music and literature. The nature of the American nation *(E Pluribus Unum)*, with especial emphasis on the Polish immigration to the United States, the geographic and occupational distribution of the present Americans of Polish descent or extraction, their contributions to America, their characteristics (good and bad) as revealed under the impact of new conditions—should be included among the subjects to be taught or lectured on within the regular curriculum of each of the proposed two Chairs.

Each Chair will have its own collection of books, a Seminar Library of say 5,000 titles, including the best books the United States has produced on its own civilization and the leading scholarly journals. Whether these books are directly donated or purchased from funds donated, each book will have a specially designed *Ex Libris* with the name and address of the donor of the book or of funds for the purchase thereof, so that the future generations of students will always know through

whose generosity a given book was made possible. This *Ex Libris* will apply also to books mentioned before, in other fields than American civilization.

It is hoped that in the Poland of Tomorrow there will be a re-orientation towards and even closer economic, political and cultural relationships with the Anglo-Saxon countries; that English will be taught in all secondary schools, if not as a required foreign language at least with first preference out of two or three; that all future scholars of Poland will be reading new American books and will be as fully informed of American progress in science and other lines of endeavor as they have been informed hereto of progress made by some of the continental nations whose languages they knew.

It would be pretentious if not preposterous to claim that everything America has produced is the best, that American institutions can be bodily transplanted into other social and spiritual climates, or that from American experience in every sphere of activity all nations can draw uniform benefits. It would be equally pretentious even to suggest to other nations that they must draw all applicable lessons from American experience in order to be happy, prosperous and progressive. However, those willing to learn can learn a great deal from America that they can adapt to their own conditions, from which they can profit greatly and which will facilitate better understanding of and therefore closer relations with America.

We have in America now over fifty Polish refugee scholars, who occupied academic positions in Poland ranging from senior assistant to full professor, including a few deans and rectors. They are learning English, and they are learning a great deal besides English. Most of them will go back and start where they left off. No, they cannot exactly start where they left off; first they will have to help rebuild and reorganize. Who knows, but the old national systems of education may

become as obsolete as the Ptolemaic system in astronomy; and some new system of education may have to be organized, around some central idea or form of international organiztion in relationship to which each national system will be revolving like a planet in the Copernican heliocentric conception! Washington may be that center, or near-center, but let us not press the analogy any further. The fact is that the impact of *American* "ideology" will be tremendous in more ways than one.

There are at least twice as many Polish refugee scholars in England as there are in America. And they, in turn, will bring with them the English version of Anglo-Saxon ideology. Again, in England, there are in the Polish Army thousands of young men with substantial intellectual background – many with interrupted university education—who will form educational cadres and intellectual leadership for the Poland of Tomorrow.

In view of the deliberate destruction by the invader of Polish intellectual capital, so as to achieve a "cultural wilderness," it seems almost inevitable that America – the United States of America—may have to "lend-lease" to Poland thousands of its teachers, professors, doctors, priests, business organizers, nurses and dietitians, builders and architects, until a new generation of Poles is raised and educated to take their places. In a good many professions, where knowledge of the Polish language is indispensable, these will have to be recruited from the ranks of Americans of Polish descent or extraction.

All these factors and considerations seem to indicate that the absorption of American contributions, of American ideas and ideals, into the life-blood of the Poland of Tomorrow, will not be as slow as has been the acceptance of the Copernican system of the universe.

THE KOSCIUSZKO FOUNDATION

What Is It? What Is It For?

ESTABLISHED IN 1925 as a living memorial to General Tadeusz Kosciuszko, the Polish national patriot and American Revolutionary War hero, the Foundation's main objective has been to promote the exchange of students and professors between Poland and the United States and to cultivate cultural and intellectual relationships between these two countries.

From the time it was organized, this Foundation has "exchanged" between Poland and America 169 students, research scholars and professors (101 Americans to Poland and 68 Poles to the United States); has granted $122,009.97 in scholarships without drawing upon its capital funds; has been instrumental in the publication of a number of books on cultural topics pertaining to both countries, and upon demand has furnished informational service in thousands of cases.

In this catastrophe that befell the Western Civilization in general and Poland's national life and cultural achievements in particular, the main objective of the Foundation has been to help preserve the brains of Poland by helping Polish scholars to survive—and when the war is over, to help in the educational reconstruction of Poland. Since 1939 the Foundation has directly aided materially and otherwise in the bringing of twelve Polish university professors to America, rendered assistance in a good many other cases of Polish intellectuals of non-academic standing and has extended material aid, whenever direct contacts were possible, to over 200 Polish refugee professors and scholars in distress scattered in several countries and continents. About 10 percent of the total

number of Polish professors and instructors as of pre-war days received aid from the Foundation. No money was or is being sent to occupied territories. Over $50,000 has been secured and spent so far since the fall of 1939 for aid of Polish refugee students and professors.

As to the Foundation's interest in the Copernican Quadricentennial celebrations—it is a part of its general interest in the promotion of intellectual and cultural relations between Poland and the United States.

The *Board of Trustees* are: WILLIS H. BOOTH, ERIC P. KELLY, HENRY NOBLE MACCRACKEN, STEPHEN P. MIZWA, PAUL MONROE, EDWARD C. SMITH, JOHN B. STETSON, M. S. SZYMCZAK, THOMAS J. WATSON, M. F. WEGRZYNEK.

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MISCELLANEA

Citizens Committees, desiring to arrange Copernican Quadricentennial celebrations or tributes in the various communities throughout the United States, are requested to use the name:

THE COPERNICAN QUADRICENTENNIAL
COMMITTEE OF (NAME OF CITY AND STATE)

Those persons from out of town who intend to be in New York on May 24, 1943, and would like to attend the Copernican Quadricentennial national celebration, are requested to communicate with the secretary of the Kosciuszko Foundation—at address given below—concerning tickets of admission.

Additional copies of this Copernican Quadricentennial brochure may be obtained at 75 cents per copy—special for schools, 50 cents per copy on orders of 20 or more—and special bound copies of the limited numbered edition at $2.50 per copy.

A limited number of copies of the same colorful drawing of Copernicus which appears on the cover design has been printed on extra heavy paper, with wide margins suitable for framing, and these prints are available at $1.00 per print.

THE KOSCIUSZKO FOUNDATION
149 EAST 67TH STREET
NEW YORK, N. Y.
Tel. RHinelander 4-7375

Anniversary To Be Marked

Queen's University plans to observe the 400th anniversary of the death of Nicholas Copernicus, astronomer and economist, on March 15 when Dr. A. Vibert Douglas, Dean of Women at the University, will speak on "The Life of Copernicus". An anthem of Copernicus's native Poland will be sung by members of the Glee Club.

The Copernician quadricentennial is being sponsored by the Kosciuszko Foundation and universities all over this continent are arranging programs to honor this great thinker.

Copernicus, described as one of the most original of Polish geniuses, first brought out the idea that the earth revolved around the sun displacing the Ptolemaic theory of a fixed earth with a sun revolving around it. He was a churchman, physician, economist, statesman, soldier and scientist which proves him one of the most versatile of men.

Polish people, not only on this continent but the world over are proud of Copernicus who is claimed by all the civilized world as its own. Today when Polish culture is being ground beneath the iron heel of Germany he is a source of inspiration to Poles and the world in general.

DISNEY ACCORDED COPERNICUS AWARD

Gazette, May 26/43

Ranked With Einstein and Ford for Contribution to Modern Living

New York, May 25. — (AP) — One Chinese and nine Americans received Copernician citations Monday as modern pioneers in pure and applied science during the quadricentennial program here commemorating the 400th anniversary of the Polish astronomer Copernicus.

The citation, bestowed by Dr. Harlow Shapley, professor of astronomy at Harvard University, Cambridge, Mass., and chairman of the Copernician Quadricentennial National Committee, which jointly sponsored the event with the Kosciusko Foundation, listed individual contributions to modern living by each of the 10 recipients.

They were: John Dewey, philosopher, New York, as "a single-minded sage;" Walt Disney, Burbank, Calif., for the "Gay, anthropomorphic humor" of his animated cartoons; Albert Einstein, Princeton, N.J., for "revolutionary concept of space, time and energy;" Henry Ford, Dearborn, Mich., for opening a "new horizon to manufacture;" Ernest Orlando Lawrence, Berkeley, Calif., for organizing "the greatest contemporary school of nuclear physics."

Also Thomas Hunt Morgan, Pasadena, Calif., for a "revolution in our knowledge of the causes and mechanisms of inheritance;" Igor L. Sikorsky, Stratford, Conn., as a "pioneer aeronautical engineer;" Wendell Meredith Stanley, Princeton, N.J., for contributions to study and control of virus diseases; Orville Wright, Dayton, Ohio, for pioneering in aviation; James Y. C. Yen, Chungking, China, inventor of an easily mastered system of written Chinese.

ishment or our indignation. How many millions of people drive a car who know nothing and care even less about what makes the thing go. Taking a reasonable and sound attitude toward a mechanical contraption which should serve us and not dominate our lives, they become interested only when it stops. But, of course, people who are supposed to keep the human anatomy going, as well as those who have to repair cars, must be informed about the contents of the mechanism they tend.

It is really a miracle of human negligence that not before 1543 *did anybody really care to find out or have the courage to investigate how the human body was "fabricated." In the beginning of our era, the Greek scholar Galen made some clever deductions on human anatomy from his observations of animal life, but it took Mr. van Wezel, who called himself in Latin Vesalius, to liberate humanity from an ignorance that was all the more astonishing as the means to do away with it were so easy.*

day the time he took home the body of a noted robber, who, "since he deserved more than ordinary hanging, had been chained to the top of a high stake and roasted alive over a slow fire made of straw, kept burning some distance below his feet. In this way a dish had been cooked for the fowls of the air, which they regarded as a special dainty. The bones, therefore, had been elaborately picked, and there was left suspended on the stake a skeleton dissected and cleaned with rare precision by many beaks. The dazzling skeleton, neat and polished, was lifted on high. . . ."

It was a proof of the fine and independent spirit of Emperor Charles V that he chose this man as his house physician and it was rather astonishing that his son, Philip II, a retrograde and a bigot if there ever was one, kept Vesalius in his service after the death of the Emperor. Vesalius was sometimes in great need of official protection, and at the end of his life he barely escaped a cruel death. The legend says that he had made

pupil of Titian. The skeletons and otherwise dissected humans do not stand at attention as they use to do in our modern encyclopaedias, looking horribly bored and impersonal. They strike all kinds of attitudes expressing sorrow, dignity, deep thinking, etc. One of them has a long knife in one hand, while with the other he holds aloft his entire skin of which he has apparently divested himself in the interest of science.

The American Medical Library Association has just printed a bulletin entirely dedicated to Vesalius' great work. Connoisseurs have pointed out that the Calcar engravings may be considered "stylistic forerunners of Surrealism" and that the anatomies of Vesalius find their counterpart in some fantasies by modern painters like George de Chirico and Salvador Dali.

These artistic comments are of course very flattering, but they scarcely do justice to the Belgian scientist, and they divert attention from the fact that Vesalius was called "probably the most important generalization of biology." In modern times, Professor Bordet's creative contributions to bacteriology earned him the Nobel Prize.

By honoring Andreas van Wezel as a Belgian scientist, therefore, the world pays tribute to a long line of scientific men who greatly advanced human knowledge and who, to a certain extent at least, made this world what it is.

Somewhere in the Talmud *(and don't ask me where, please) it is said that one should be grateful to anyone from whom one learns a sentence, a word or even a letter. It is a good thing that at least in the free world today people express their admiration and their gratitude to that Belgian scientist who, 400 years ago, found a little truth we were missing, and who, although people called him "an impious madman whose breath poisoned Europe," went about his business of telling us about our sinews and*

VOL. III, No. 33 AUGUST 14, 1943

ADVANCE PROOF

News from Belgium

and the Belgian Congo

Belgian Information Center 630 Fifth Avenue, New York, N. Y.

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"Modern Medicine Begins Here"

At times, war seems to be as hard on some from Brussels, one Andreas van Wezel, born dead people as it is on the living. Le[illegible] world

COPERNICUS, De Revolutionibus, 1543;
translation made by Miss Parker of the
Bodleian Library, 1918, of the preliminary
matter and inserted in the Osler Library
copy, No. 566.

To the Reader

Concerning the Hypotheses of this work.

Anon. - by Andreas Osiander

I do not doubt that certain learned men will be much annoyed at the common report of the newness of the arguments of this work, namely, that the earth is movable, but that the sun is immovable in the middle of the universe, and will think that noble doctrines rightly established in the past should not be disturbed. But if they will consider the matter closely, they will find that the author of this work has done nothing worthy of blame. For it is the part of an astronomer to draw up an account of the celestial movements from earnest and skilful observation, and then (when he cannot arrive at the real causes of these things) to think out and invent any hypotheses whatsoever and take them for granted, if thereby these same motions may be rightly calculated, both for the future and for the past, by the principles of geometry. Now this writer greatly excels in each of these points. For it is not necessary that these hypotheses should be true, or even very probable, but this one thing is sufficient, that they must put forward a calculation agreeing with the observations. Unless by chance anyone be so very ignorant of geometry and optics that he holds the epicycle of Venus to be probable, or believes that it is the cause of its being in forty parts, and still further that it sometimes precedes and sometimes follows the sun. For who does not see, when this is taken for granted, that it necessarily follows that the diametre of a star when nearest the earth is greater by more than fourfold, and its body is greater by sixfold than it appears when furthest from the earth, which however the experience of all the ages contradicts? And there are other things not less absurd in this teaching, which it is not necessary to discuss here. For it is clear enough that this art entirely and simply ignores the causes of apparent unequal motions. And if he devises these causes by invention, as he certainly does very many, by no means however does he discover this, that he can convince anyone that they are true, unless they rightly form a calculation. When various hypotheses of one and the same motion sometimes offer themselves (as in the motion, the eccentricity, and epicycle of the sun) the astronomer will choose for preference that one which is most easily understood. The philosopher perhaps will require a greater exactitude; neither however will understand or propound anything true unless it has been revealed to him by divine providence. Let us therefore allow these new hypotheses to be known as no less probable than the old ones, particularly as they are at the same time wonderful and easy, and bring with them a huge treasury of most learned observations. Let no one expect anything true, pertaining to hypotheses, from astronomy, for it can show nothing of the sort, lest taking false things for true in some other use, he depart from this teaching more foolish than he came. Farewell.

Nicholas Schönberg Cardinal of Capua,
to Nicholas Copernicus, Greeting.

Having constantly heard, from the lips of all men, of your talent, I have begun to honour you more fully, and to congratulate our countrymen amongst whom you have flourished with so great renown. For I had perceived that you were not well versed in the works of the old mathematicians, but also had propounded a new theory of the universe. By it you teach that the earth moves, that the sun is at the bottom of the universe, and indeed holds the middle place. That the eighth heaven remains immovable and eternally fixed. That the moon, with the elements included in her sphere, placed between the heaven of Mars and Venus, revolves in a yearly course round the sun. And that you have written commentaries on this whole theory of astronomy, and have reduced into tables the motions of the planets, computed from calculations, to the great admiration of everyone. Wherefore I beseech you, most learned man, if I am not troubling you, to impart this your discovery to the learned, and also to send to me in the first place your lucubrations concerning the sphere of the universe, with the tables, and anything else you have besides belonging to the same matter. Also I have commissioned Theodoricus a Reden, to transcribe and send to me everything concerning the matter, at my own expense. And if you will gratify me in this, you will find that you have to do with a man careful of your name, and one anxious to do justice to such great talent. Farewell. At Rome, Calends of November, 1536.

To the Most Holy Lord Pope Paul III.
The Preface of Nicholas Copernicus on the Books of the Revolutions.

I can see clearly enough, O most holy Father, that it will happen that certain people, while approving of my attributing certain motions to the globe of the earth, in these my books concerning the Revolutions of the spheres of the universe, will yet exclaim that I ought to be reproved for such an opinion. But as my own things do not please me, so I do not consider what others may judge concerning them. And although I know that the reflexions of the philosopher are far removed from the understanding of the common man, because his work is to find the truth in everything, as God has allowed to human reason, yet I think strange doctrines, far removed from truth, should be avoided. Thus I thought to myself what an absurd report they would think it, who do not know the opinion confirmed by the judgment of many centuries, that the earth is immovable in the middle of the heavens, being as it were in the centre of it, if I should assert on the contrary that the earth moved; thus for a long time I hesitated whether I should publish my commentaries on its movement, or whether indeed it would be better to follow the example of the Pythagoreans and some others, who used not to transmit the mysteries of philosophy by letters, but by word of mouth to their neighbours and friends only, as the letter of Lysis to Hipparchus shows. And indeed this seems to me to have been done, not as some think from some jealousy of communicating their theories, but lest the noblest things, studied by great men with much care, should be despised by those who are too indolent to expend much labour on any work except for gain, or those who if they are stimulated by the exhortation and example of others to the study of philosophy yet by the dullness of their wit would remain among philosophers like drones among bees. When therefore I thought on these things, the contempt which I feared on account of the novelty and absurdity of my opinion, almost compelled me to discontinue this treatise altogether.

But as I hesitated and resisted for a long time, my friends urged me on, among whom was first Nicholas Schönberg, cardinal of Capua, famous in every kind of learning; next to him was my most loving friend Tideman Cisius, bishop of Culm, most learned in the sacred writings as in all the other sciences. For he again and again exhorted and entreated me with reproaches for a long time to publish this book, and allow it to be

brought into the light, which had lain hidden with me not only for nine years, but even into the fourth novennium i.e. more than 27 years . Many other very eminent and learned men did the same, praying me no longer to refuse, on account of imaginary fears, to deliver up the fruits of my labours for the common good of students of mathematics. For the more absurd my theory of the motion of the earth appeared to be, so much the more admiration and favour would it have when the mist of absurdity was cleared away by the clearest proofs, when my commentaries were published. So yielding to their persuasions and upheld by this hope, I at length permitted my friends to publish the work, which they had so long besought me to do.

But your Holiness will not perhaps so much wonder that I have dared to bring to light these my lucabrations and after taking so much trouble in elaborating them, that I have not hesitated to commit my opinions concerning the motion of the earth to writing, but rather will expect to hear from me what I was thinking of to dare to attribute any motion to the earth against the accepted opinion of mathematicians, and also against common sense. Thus I will not hide from your Holiness that nothing else has moved me to consider any theory for reckoning the motions of the spheres of the universe except the fact that mathematicians do not agree among themselves in those researches. For in the first place, as long as they are uncertain about the motion of the sun and moon, they cannot observe and demonstrate the eternal magnitude of the returning year. Then in determining the motions both of these and of the other five planets, they do not use the same principles and assumptions, and demonstrations of visible revolutions and motions. For some use homocentric circles only, others eccentric and epicyclic ones, by which however they do not fully achieve what they desire. For those who have trusted to homocentric circles, although they have shown that some different motions may be made from them, have been able to conclude nothing certain therefrom, which should correspond exactly to the phenomena. For those who have studied eccentrics, although they seem in great part to have solved the apparent motion, when the numbers agree, yet at the same time they have admitted many things which seem to oppose the first principles of the equality of motion. They have not been able to find or to deduce from them the chief thing of all, which is the form of the universe, and the exact symmetry of its parts. But it may happen with them, for example, as if in order to portray a man, one should take from various places, hands, feet, head and other parts of the body, all perfect in themselves, indeed, but not belonging to one body, and in no wise corresponding to each other, so that one would have formed a monster rather than a man. Thus in the process of demonstration, which they call method, they are found to have omitted something necessary, or to have admitted something quite foreign to the subject. This would not have happened to them if they had followed true principles. For if they had not assumed false hypotheses, all the things which followed from them could be verified without doubt. Although these things seem obscure as I am telling them, they will appear more clear in their proper place.

When I had for some time been considering the uncertainty of mathematical traditions in determining the motions of the spheres of the universe, it began to trouble me that no more true theory for the construction of the motions of the spheres of the universe, which according to us was established by the best and most exact of workmen, should have been determined by philosophers, who in other matters concerning it had made such minute investigations. Wherefore I made it my work to refer to the books of all the philosophers which I could get, to find out whether any had been of opinion that there were other movements of the spheres of the universe than the ones put forward by those who professed mathematics in the schools. And I found in Plutarch that some others were of the same opinion, whose words, that they may be known to all, here follow:

"Others say that the earth stands still: but Philolaus the Pythagorean says that it turns round the sun in an oblique circle in the same way as the sun and moon. Heraclides of Pontus and Ecphantus the Pythagorean, make the earth go round, not by changing its place, but like a wheel, rotating from west to east round its own axis."

When therefore an opportunity occurred, I began to reflect upon the mobility of the earth. And although the idea seemed absurd, yet because I knew this liberty had been granted to others before me, to make circles to demonstrate the phenomena of the stars, I thought that I also might discover whether clearer proofs of any movement of the earth then these could be found in the revolution of the celestial orbs.

And thus, these motions which I attribute to the earth in the following work, being granted, at length by long and careful observation I found that if the motions of the other planets are compared with the revolution of the earth, and are reckoned as the revolution of each star, not only do their phenomena follow, but also the orders and magnitudes of all the stars and orbs and the heaven itself so united them, that nothing may be transposed in any part of it, without confusion of the other parts and of the whole universe. And the order which I have followed in the progress of the work, is, that in the first book I describe all the positions of the orbs, with the motion which I attribute to the earth, so that it contains as it were the general formation of the universe. In the remaining books I afterwards compare the motions of the other stars and orbs with the motility of the earth, so that thence it may be determined how the movements and appearances of the other stars and orbs will stand if compared with the motions of the earth. I do not doubt that clever and learned mathematicians will agree with me, if, which this philosophy particularly demands, they will examine, not carelessly, but with diligence, the things which are offered in proof of these things. So that both learned and ignorant may see that I have in no wise avoided the judgment of anyone, I prefer to dedicate these my lucubrations to your Holiness, rather than to anyone else, because in this remote corner of the earth in which I live you are considered most eminent, both in the dignity of your order, and in your love of all learning and mathematics, so that you may repress by your authority and judgment the slander of false accusers, although according to the proverb there is no remedy against the bite of a sycophant.

If there be any who, though ignorant of mathematics, shall presume to judge concerning them, and dare to condemn this treatise because they fancy it is inconsistent with some passages of scripture, the sense of which they have miserably perverted, I regard them not, but despise their rash censure. It is well known that Lactantius, in other respects a famous writer, yet very little of a mathematician, speaks very foolishly of the form of the earth when he scoffs at those who believed that the earth was round. Thus it should not be wondered at by students if such as these should also deride us. Mathematics are written for mathematicians, and unless I am mistaken these our labours for them will contribute something of use to the Church, of which your Holiness is now the head. For, some little time ago, under Pope Leo X, at the Lateran Council, not only was the question debated of reforming the ecclesiastical calendar, but it remained unsettled, because the magnitude of the years and months, and the motions of the sun and moon, were not yet sufficiently determined. From that time I applied myself to observing those things more accurately, by the advice of the most renowned Paul, bishop of Sempronia, who was foremost in this affair. Now what I have put forward in this work I leave to the judgment of your Holiness chiefly, and then to that of all other learned mathematicians, and lest I seem to promose more usefulness in this work than I can show, I now pass on to the treatise.

McGILL UNIVERSITY
MONTREAL

OSLER LIBRARY,
8 February 1943.

Dr. A. Vibert Douglas,
Queen's University,
Kingston,
Ont.

Dear Dr. Douglas,

I am sending you the translation herewith. It was merely a matter of copying. I did not have to do the translating. That was done by the first, and at that time, the only woman member of the staff of the Bodleian Library. She was a bit of a Tartar, known behind her back as Poggy, and everybody, including the Librarian, went in fear of her. Keep the copy as long as you want to, permanently, if it would be of any further use to you.

I have heard from the Sigma Xi president, and have accepted his kind invitation to the preliminary dinner and the meeting, and to bring the two books and speak about them.

Yours sincerely,

W. W. Francis.

WWF:CD
Encl:-

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February 20, 1943

Dr. A.V. Douglas
Office of the Dean of Women
Queen's University
Kingston, Canada

Dear Dr. Douglas:

I want to thank you very much for your fine letter of February 11th and your complimentary remarks about my little book on Nicolas Copernicus.

As you are undoubtedly aware, I am not an astronomer and this booklet of mine is merely intended to tell the life story of Copernicus on which question unfortunately there is so little material in the English language. As it happens, the English and American literature on the subject is quite adequate on the purely scientific or astronomical phases of Copernicus and his contributions, but hopelessly deficient and warped on the biographical side. For example, you mention the book by Angus Armitage. I do not happen to possess it, but I read it in the library. It is really an admirable book and practically the best thing on Copernicus in the English language but it reveals one painful feature of all Anglo-saxon scholars who relied on German sources. The outstanding Copernican scholar has undoubtedly been Ludwik Antoni Birkenmajer, Professor of History of Science at the Jagiellonian University of Krakow who died in 1929 but unfortunately he did not complete for publication his monumental work on Copernicus giving a synthesis of his, that is Birkenmajer's life work.

Those things which he published were written either in Polish or consisted of original Copernicana materials which he discovered in various archives including Sweden but not previously known to scholars. Of some of his publications brief translations in the French language occurred but on the whole his works were not accessible to foreign scholars. That is where the difficulty lies.

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February 20, 1943

English and American scholars who read German and not having direct access to the results of Polish scholarship printed in Polish, relied principally if not exclusively on German works more specifically Leopold Prowe's "Nicholas Coppernicus" published in Berlin in two volumes in 1883-84.* That is the work on which Mr. Armitage principally relied, I believe, for his second chapter - "The Life Story of Copernicus" and he unintentionally fell into the German trap concerning the nationality of Copernicus. I do not recally the exact wording but if I remember correctly it was on page 26 or thereabout where Armitage comes to this conclusion, following Dr. Prowe: In view of the fact that Thorn (Toruń) the city where Copernicus was born and Cracow where he received his first university education were German cities, founded by Germans, the conclusion seems to follow that Copernicus was a German.

I think that such a slavish following of German arguments by a reputable scholar like Armitage is wholly unjustifiable. If Mr. Armitage had only taken the trouble to look it up in such a reference work as the Encyclopaedia Britannica under Cracow, he would have learned that that city was founded by the Poles as a stronghold even before historic times and in the year 1000 became a seat of a bishopric. The Germans were not invited to Polish cities until after the Tartar invasion of 1241 when the cities were practically depopulated and Polish kings invited German colonists to settle in Polish cities.

Cordially yours,

Stephen P. Mizwa
Executive Director

SPM
wtg

* Dr. Prowe spent all his active life, about 50 years, in his passionate desire to prove the German nationality of Copernicus. Traces of his arguments are detected in practically all works on and references to Copernicus, in the English language.

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February 3, 1943

Because of your special interest in astronomy, and therefore in Copernicus, this brochure is being sent to you with my compliments with a hope that you will find it useful in connection with the coming Copernican Quadricentennial. The Copernican Quadricentennial National Committee is headed by Prof. Harlow Shapley as Chairman.

Anything you can do within the realm of your institutional contacts and possibilities for the commemoration of this event, will be greatly appreciated.

Cordially yours,

Stephen P. Mizwa
Secretary

MCGILL CHAPTER

SOCIETY OF THE SIGMA XI

For the promotion of research in Science

A meeting will be held on Friday, March 26th, at 8.15 P.M. in the Main Lecture Theatre at the PHYSICS BUILDING, McGill University.

SUBJECT: "COPERNICUS, (1473 - 1543) - A COMMEMORATION LECTURE"

SPEAKER: DR. A. VIBERT DOUGLAS, M.B.E., F.R.A.S., President of the Royal Astronomical Society of Canada, Queen's University, Kingston, Ontario.

This year marks the four hundredth anniversary (May 24) of the death of Copernicus, who is thought of principally as a mathematical and astronomical genius. He was however, more than this; in addition to practising medicine he published a treatise on Polish currency reforms, took part in the defense of his country as Commander-in-Chief of the Polish forces of the beleaguered city of Olsztyn and vigorously discharged his duties as Canon of the Cathedral of Frauenburg. It is true then that "his legacy to the world was an upright, useful life and a volume containing an immortal truth:- the earth is not the centre of the universe; the earth is in motion around the sun". Edward S. Holden). With our universities facing the criticism that neither Liberal Arts nor Science is producing people of the type required it will be interesting to hear Dean Douglas's account of this man and his works.

DR. W.W. FRANCIS, Osler Librarian and Director of the Museum of the History of Medicine, McGill University, will bring to the meeting and will comment upon, the first editions of Copernicus's masterwork "De Revolutionibus Orbium Coelestium" and also Vesalius's book "De Humani Corporis Fabrica", both 1543.

Some fees are still due - payable to the treasurer, DR. GORDON PALL, ENGINEERING BUILDING, McGILL UNIVERSITY. Members; $1.50; Associates; $1.00.

Rhoda Grant, Secretary,
Physiology Department.

March 19, 1943.

what happened, for instance, to a gentleman

Vesalius obtaining his first sketeton outside the walls of Louvain

was set and ready to celebrate the 400th anniversary of his birth, Kaiser Wilhelm, the great promoter of fresh and envigorating warfare, was taking up all the space in the newspapers and celebrations had to be postponed indefinitely.

This year, 1943, a lot of scholarly individuals wanted to draw the attention of the world to the fact that 400 years ago the same Mr. van Wezel had published a most remarkable book. Immediately a buffoon of the first magnitude, one Benito Mussolini, succeeded in diverting the world's attention from all academic pursuits. Therefore, it seems right and just that, abandoning present-day history for once and turning from our Belgian wailing wall, we go back into Belgium's past to do justice to a man who, according to those who know, was a real benefactor of mankind.

To a certain extent, all of us are interested in anatomy, but most people — caring only about the pleasant side of it — stop at the surface and disregard what is going on inside. This should not provoke our aston-

In 1543 he published, in Basel, what is perhaps the greatest achievement of Belgian science, his book on the construction of the human body: De Humani Corporis Fabrica. *It is considered as ranking among such publications as Copernicus' book on the* Revolution of the Spheres, *Adam Smith's* Wealth of Nations *and Darwin's* Origin of the Species. *It has been said by authoritative men that with Vesalius' book "modern medicine begins." It has also been said that his great work is "one of the most nobly illustrated volumes in the world."*

Vesalius had to fight the prejudices of the Church as well as those of the medical profession — no small undertaking. To some Church people his work looked like desecration. To the medical faculty, he seemed a troublesome, revolutionary spirit who dared to doubt the authority of the scientific demigod Galen. It must be said that his methods of investigation were bound to arouse suspicion. He specialized in taking the bodies of executed criminals from the gibbets and the gallows. In Louvain he had a real field-a study of the corpse of a young Spanish nobleman. The combined efforts of the gentlemen of the Inquisition, of the members of the Faculty of Medicine and of the young man's relatives were to prove that the object of Vesalius' anatomical carvings was not completely dead when the great physician was already dissecting his nerves and bones. These three groups of people feared that, especially in this case, haste was of the devil.

Reaction was so strong that Vesalius, although getting away with his life, had to go on a pilgrimage to Jerusalem to expiate his sin of inquisitiveness. He died on his way home on the island of Zante, which Homer so lovingly called "wood-shaded Zakynthos."

Vesalius' work on the human body was published when he was 28 years of age. Apart from a theoretic exposé, it contained a great number of beautiful engravings representing the human body and skeleton in different states and attitudes. These remarkable engravings were made by a Flemish artist Jan van Calcar, a talented

a link in the impressive chain of Belgian scholars who have contributed, down through the ages, to the advancement of medicine and surgery. Before Vesalius, there was Jan Yperman (1294-1357), *who wrote a masterly treatise on surgery. A contemporary of Vesalius, Dodonaeus, greatly contributed to the development of pathological anatomy, and his studies on plants and herbs are still of basic importance. Dr. Palfijn* (1721) *invented the forceps, and in the field of physiology Dr. Theodore Schwann discovered the animal cell. This discovery*

man when he sang "The Body Electric" and its:

"Strong shoulders, manly beard, scapula, hind-shoulders, and the ample side-round of the chest,

Upper-arm, armpit, elbow-socket, lower-arm, arm-sinews, arm-bones,

Wrist and wrist-joints, hand, palm, knuckles, thumb, forefinger, finger-joints, finger-nails. . . ."

—THE EDITOR.

Drawing page 257 reprinted from *The Human Body* by Logan Clendening, by permission of and special arrangement with Alfred A. Knopf, Inc. COPYRIGHT—1927-1930-1937 by ALFRED A. KNOPF, INC.

The History of a German

A broadcast over the Belgian National Broadcasting System in London.

Following is the very edifying story of Martin Niemoeller. This typical story, which seems almost like a parable, deeply stigmatizes Germany, the 100 per cent German, the eternal German. Added to the thousands of other examples of the same type, it is just one more testimony to refute the thesis of the "good German" and the "bad German." There are too many people who still discriminate between the German and the Nazi, who see the Nazi as a hideous monster,

Nicholas Copernicus

THE QUADRICENTENNIAL CELEBRATION OF THE POLISH INSTITUTE

Reprinted from the Quarterly Bulletin of the Polish Institute of Arts and Sciences in America, July, 1943

Nicholas Copernicus

THE QUADRICENTENNIAL CELEBRATION OF THE POLISH INSTITUTE

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THE COPERNICAN QUADRICENTENNIAL

Introduction

On May 24 of this year, the whole civilized world celebrated the four-hundredth anniversary of the death of the famous Polish astronomer Mikołaj Kopernik, and of the publication of his epoch-making book "De Revolutionibus Orbium Coelestium."

In America the celebration of that anniversary has been so admirably prepared by the KOŚCIUSZKO FOUNDATION, that the Polish Institute of Arts and Sciences had only to join a movement which had been started long before its inauguration.

The Director of the Institute was invited to become a member of the National Copernican Quadricentennial Committee, presided by Professor Shapley, of Harvard University, with Professor S. P. Mierzwa, Executive Director of the Kościuszko Foundation, as national Secretary. He was one of the speakers at the National Celebration, held on May 24 at Carnegie Hall, New York City, where he delivered the greetings of the Polish scholars who now are temporarily silenced, and an address on Poland's Golden Age in the time of Copernicus. He also spoke at some other Copernicus celebrations, organized in Pittsburgh (University of Pittsburgh), Cleveland (Western Reserve University), Toronto (University of Toronto), and New York (New School for Social Research). Several members of the Institute were also among the speakers at various Copernicus Commemorations, as, for instance, Professor H. Arctowski in Baltimore, Professor W. Lednicki in Boston, and Professor E. Zawacki in Chicago.

Since the whole material concerning the various celebrations will be collected and published by the Kościuszko Foundation, we are publishing here only the lectures which have been delivered at ceremonies organized by the Polish Institute itself, viz. at its public session of May 3, and in Chicago, by our Midwest Branch. We are printing first the three lectures by American and foreign scientists who discussed Corpernicus as an astronomer, and then the four addresses by Polish or Polish-American scholars, who described his life and his national background. Professors L. Karpiński, A. Koyré, R. Taubenschlag, W. Lednicki and O. Halecki spoke in New York, on May 3rd, and Professors O. Struve and E. Zawacki—in Chicago, on May 23rd.

COPERNICUS, FIRST CITIZEN OF A NEW WORLD ORDER

By PROFESSOR LOUIS C. KARPINSKI
University of Michigan
President of the History of Science Society

The genius is the man who chooses properly the time, the place and the role of his appearance on this earthly stage, in a play with companions of his selection. Not transcendent genius and not even the capacity for hard work are as vitally important to produce a genius as the historically correct moment.

Copernicus chose to devote his life to the most ancient of all studies, that of the movements of the heavenly bodies. As the achievement of Copernicus was part and parcel of the progress of human thinking about these movements, it is necessary in order to properly place his contribution to sketch the developments in the history of mathematical science upon which Copernicus based his work.

Particularly in Babylon and in Egypt the clear atmosphere lent a brightness to the planets and the stars, which forced the wanderings of the one group and the flickering and variable lights of the other upon the attention of man. Here in the Near East the first definite progress was made to apply to astronomical observations the numerical treatment of angles and associated lengths, which is the essence of our trigonometry. The Babylonians began the 60 minutes and 60 seconds system of time, with the 12 double-hour day and the seven-day week, which continue to the present day. Further the division of the circle into 360°, or four quadrants of 90° each, this also goes back to ancient Babylon, together with an understanding of the Pythagorean theorem that in a right triangle the square on the hypotenuse equals the sum of the squares on the other two sides. This theorem is to the present day also essential for trigonometric determinations of the right triangle, and for the functions of the angles of 30°, 45° and 60° and related angles. The Babylonians combined with these studies diligent observation of the stars and planets, and particularly a study of the periods of planetary motion and the precise determination of the periods of eclipses, notably of sun and moon.

The Babylonians and the Egyptians made progress also in arithmetical and algebraical ideas which became essential for further mathematical developments.

The progress of knowledge concerning the motions of the heavenly bodies continues with the ancient Greeks. Archimedes had a well-developed trigonometry of chords, but this was replaced about 150 A. D. by the systematic trigonometry of chords by Ptolemy, the geographer. Long before this, plane geometry and even solid geometry had been quite completely developed in Greece. Applications including a really scientific astronomy were a part of the Greek achievement.

The difficulties of explaining the three observed motions of the earth—or the heavens—was attacked early in Greece by assuming circular motions for the heavenly bodies moving about a fixed center, combined by Eudoxus with allowing the moving point on a circle to become the center of circular motion of another moving point. This motion produces curves called epi-cycloids. In Greek astronomy these curves served the purpose of making possible a mathematically sound explanation of the observed motions, including that of the apparent retrograde (or reversal of direction) motion of some of the planets.

Aristarchus of Samos, about 325 B.C., is the first astronomer known to have discussed mathematically the relative distances of sun and moon from the earth. This Greek proposed to take the sun as the center of the universe. Copernicus indicates by a reference to the Aristarchus theory in the first edition of the *De revolutionibus* a wide acquaintance with early Greek astronomy. Later one Heraclides introduced a variant hypothesis in Greece which also seems to have influenced the Copernican astronomy.

However, the Ptolemaic system of the universe, with the earth as center, was explained so well, prefaced by a trigonometry of chords, that the textbook, known later as the Almagest, became the handbook of Eurasian astronomy for a period of 1400 years, from the time of the Greek Ptolemy to the Polish Copernicus. The same Ptolemy, about 150 A.D., wrote a geography using observed latitudes and longitudes of cities and countries, which were duly recorded with maps. This geography of Ptolemy became the accepted textbook for 1500 years. In the transmission of Greek, Hindu, and Arabic mathematical science to Europe, the two Ptolemaic works

occupied a central place. Many Greek works were translated first into Arabic and thence into Latin or Hebrew.

From the far East of India there came to the Arabic speaking peoples of the Near East knowledge of certain crucial mathematical developments destined to transform the mathematics of Europe, particularly in the applications to astronomy, physics, and geography.

The Hindus presented a simplified arithmetic and renewed the systemization of algebra, begun by the Babylonians. The introduction of the sine function, the half-chord, together with the shadow or cotangent function, prepared the way for a wholly new trigonometry, far better adapted to numerical situations. With the trigonometric functions was introduced that which prepared the way for the application of the mathematical methods of the calculus to physical problems. Quantity production and machinery, even the printing press, is dependent on the "round and round" motion which is characteristic of trigonometry.

The Arabs became then the heirs of the past ages, combining in their works the accumulated mathematical developments of Hindus and Greeks and others whose contributions are lightly touched on above. The Arabs elaborated the trigonometric tables and a systematic science of plane and spherical trigonometry, making many notable contributions. As excellent textbook writers, the Arabs served Europe well, transmitting material largely due to the Hindus; practically the whole range of mathematical material of arithmetic, algebra and trigonometry now given in our high schools was covered by Arabic systematizations.

The Arabs, Persians and Syrians, the Moslem group, held the torch of learning in Eurasia from 700 to 1300 A.D., yea, with the Mongols, even to 1450 A.D. It is hardly possible to indicate briefly that the mathematics and astronomy, with optics, architecture, geography, engineering, and medicine were all seriously studied and notably advanced as sciences by the Moslems. Through the portals of Spain the civilization of Europe made its contacts with the intellectual treasures of the Near East. Those who truly cultivate the sciences have in ages past been desirous to impart the knowledge to others. The cultivation of beauty and the esthetic in clothes, ornaments and habitations, and also foods, has always accompanied the development of mathematical ideas. This made it easier for the Moslems and their beautiful women to influence their European

neighbors. "Chemise," for example, is an Arabic word with many of the implications of civilization.

So far as the mathematical and astronomical material necessary for the progress to a new universe is concerned, that was the joint product of the Arabic-Spanish schools of the West and the Persian-Arabic schools of the East. The contributions of Alphonse the Wise as well as those of the Portuguese represented so well by Prince Henry the Navigator and Bartholomew Diaz, included new mathematical tables, new astronomical instruments and maps. Some of this activity reached a culmination, in a certain sense, in a new order of the universe presaged by the Columbus and Vespucci discovery of the New World. In the East the plane trigonometry of Nasir al-Din al-Tusi (1276 A.D.) provided the mathematical machinery that with new tables revolutionized the trigonometric methods, making it possible to develop a simplified astronomy.

The translation of the tremendous wealth of Arabic scientific material as accumulated in the four hundred years from about 775 A.D., began to be put into Latin and Hebrew by Christian and Jewish translators of the twelfth and thirteenth centuries. Sarton has well indicated in his immense volumes on the History of Science, published by the Carnegie Institution, that the amount of the scholarly material became so great that the universities were founded for the classification of knowledge, an indispensable necessity for the assimilation by Europe of the new learning.

The European printing press of 1450 must be recognized as the greatest instrument created by man for the democratization of learning. For the first time in history quantity production, applied to books, was able to place in the hands of thousands of capable students the instruments for self-instruction in the learning of the past ages.

To properly appreciate the greatness of the new universe which gradually emerged after the Copernican theory gained acceptance, it is essential to know that printed books were the instruments which made the emergence possible. No human mind by itself alone, not the greatest of human intellects, could reveal the majestic harmonies of the material universe without having the literature of the past ages at his disposition.

Plato, Archimedes, Ptolemy, Copernicus, Kepler, Galilei, and Newton were all men of transcendent intellectual ability. Their connected contemplations of the celestial sphere in its nightly and yearly

progressions—even that was not made by their work alone. Scores and hundreds of astronomers, physicists and mathematicians labored before them, with them and after them in order to make the Newton an well ordered universe possible. The continued success of the conquest of the physical world by astronomers and physicists and mathematicians revealed certain irregularities in the night life of the moon and the sun, even as with man. Certain phenomena of the eclipses could not be explained by the Copernican-Keplerian-Newtonian system. Then there appears upon the scene a modest little man, Albert Einstein, now living over the river in Jersey, whose intellect, intelligence and mathematics were equal to the task.

If man was born to sin, planets were born to wander and stars to shine with irregular brightness. That is the way of life. In ages to come, others will come to bring the further irregularities to book —thus to restore harmony again, which is what the human mind and soul crave.

Poland's son Copernicus had that Christian greatness, which enabled him to abdicate the astronomical throne, that is to remove the earth as a center of power and to substitute the sun as center. With the sun as center, the earth becomes a minute and relatively inconsequential member of a universe with myriads of more important members. Thus according to the Copernican theory, myriads of other universes greater than ours may exist and may have life and intelligent beings on their surfaces.

In these so sorely troubled times is there not a call for all of us, Poles and Russians and Americans, English, Chinese, Dutch, East Indians, Burmese and Scandinavian, Belgians and French, to contemplate from some similar height our little universe? Let us dedicate ourselves to the task, that this struggle shall not have been in vain, and that the world in which we live may make for the hundreds of our brethren who have lived without knowing the benefits of modern science or of modern civilization a new order, a new order in which all men shall be brothers. The peasant populations of all the countries of Europe, with the under-privileged who still exist on the American continent, may then find a more decent world, where the rights of man, God willing, will be the center of our economic system, the center of a universal and democratic way of life.

APPENDIX

COPERNICUS-BIBLIOGRAPHY IN THE UNIVERSITY OF MICHIGAN LIBRARY

By

SISTER M. CLAUDIA ZELLER, O.S.F.

Original Works

1. Nicolai Copernici Torinensis *De revolvtionibvs orbium coelestium,* Libri VI. Habes in hoc opere iam recens nato, & ædito, studiose lector, Motus stellarum tam fixarum, quàm erraticarum cum ex ueteribus, tum etiam ex recentibus obseruationibus restitutos: & nouis insuper ac admirabilibus hypothesibus ornatos. Habes etiam Tabulas expeditissimas, ex quibus eosdem ad quoduis tempus quàm facillime calculare poteris . . . Norimbergæ apud Ioh. Petreium, Anno M.D.XLIII.

6p. l., 196 numb. l. tables, diagrs. 26½ cm.

2. Nicolai Copernici torinensis *De revolvtionibvs orbium coelestium,* libri VI. In qvibvs stellarvm et fixarvm et erraticarvm motvs, ex veteribus atque recentibus obseruationibus, restituit hic autor. Præterea tabulas expeditas luculentasque addidit, ex quibus eosdem motus ad quoduis tempus mathematum studiosus facillime calculare poterit. Item, De libris revolvtionvm Nicolai Copernici narratio prima, per M. Georgium Ioachium Rheticum ad d. Ioan Schonerum scripta. Cum gratia & priuilegio caes. maiest. Basileæ, ex officina Henricpetrina [1566].

6 p. l., 213 numb. l., 1 l. tables, diagrs. 29 cm.

3. Nicolai Copernici Torinensis. Astronomis istavrata, libris sex comprehensa, qui *De revolutionibus orbium caelestium* inscribuntur. Nunc demum post 75 ab obitu authoris annum integritati suæ restituta, notisque illustrata, opera & studio d. Nicolai Mvlerii . . . Amstelodami, excudebat Wilhelmus Iansonius, sub Solari aureo, MDCXII.

11 p. l., 487 p. tables, diagrs. 23½ cm.

4. Nicolai Copernici Thorvnensis *De revolvtionibvs orbivm coelestivm,* libri VI. Ex avctoris avtographo recvdi cvravit Societas copernicana thorvnensis. Accedit Georgii Ioachimi Rhetici De libris revolvtionvm narratio prima. Thorvni, svmptibvs Societatis copernicanæ, 1873.

xxx p., 1 l., 494 p. tables, diagrs. 35½ x 28 cm.

5. *De lateribvs et angvlis triangulorum,* tum planorum rectilineorum, tum sphaericorum, libellus eruditissimus & utilissimus, cum ad plerasque Ptolemæi demonstrationes intelligendas, tum uero ad alia multa, scriptus à clarissimo & doctissimo uiro d. Nicolai Copernico Toronensi. Additus est

Canon semissium substensarum rectarum linearum in circulo. Vittembergæ, excusum per Iohannem Lufft. M.D.XLII.

[59] p. incl. tables, diagrs. 20 x 15½ cm.

Edited by G. J. Rhæticus (1514-1576).

Photostats of this book at UM.

Translations

1. . . . *Des révolutions des orbes célestes;* traduction, avec introduction et notes par A. Koyré . . . Paris, F. Alcan, 1934.

2p. l., [vii]-xiii, 154 p. 1 l., diagrs. 19 cm.

2. *Three Copernican Treatises*: the Commentariolus of Copernicus, the Letter against Werner, the Narratio prima of Rheticus; translated with introduction and notes by Edward Rosen . . . New York, Columbia University Press, 1939.

x p., 2l., [3]-211, [3] p. diagrs. 23½ cm.

3. *The Commentariolus of Copernicus,* by Edward Rosen.

(In Osiris. Bruges, Belgium, 1937. vol. 3 p. [123]-141).

4. Traictie de la première invention des monnoies de Nicole Oresme; textes français et latin d'après les manuscrits de la Bibliothèque impériale, et *Traité de la monnoie de Copernic;* texte latin et traduction française. Publiés et annotés par M. L. Wolowski . . . Paris, Guillaumin et cie., 1864

lxxii, cxxxix, 83 [1] p. 28 cm.

5. . . . *La monnaie; entretien sur le traité de la monnaie de Copernic,* par L. Wolowski . . . Paris, Didier et cie., 1864.

52 p. 19 cm.

6. *Nicolaus Coppernicus aus Thorn Über die Kreisbewegungen der Weltkörper.* Übersetzt und mit Anmerkungen von dr. C. L. Menzzner, Durchgesehen und mit einem Vorwort von dr. Moritz Cantor. Hrsg. von dem Coppernicus-verein für Wissenschaft und Kunst zu Thorn. Thorn, E. Lambeck, 1879.

xxii, 363, 66 p. tables, diagrs. 24½ cm.

Biographical Material

1. *Copernicus, the Founder of Modern Astronomy,* by Angus Armitage . . . London, G, Allen & Unwin, Ltd., (1938).

183 [1] p. incl. front. (port.) diagrs. pl. 22 cm.

2. *Copernic et ses travaux,* par. M. J. Bertrand . . . [Paris, Imprimerie, 1864].

23 p. 26½ x 21½ cm.

3. *Mikołaj Kopernik.* Część pierwsza: studya nad pracami Kopernika oraz materiały biograficzne. Opracował i zebrał Ludwik Antoni Birkenmajer. W Krakowie, Księgarnia Spółki wydawniczej polskiej, 1900.

xiii, 711 p. incl. illus., tables, plates, facsim. 29 cm.

4. *Kopernic et ses travaux.,* par Jean Czyński . . . Paris, J. Renouard et cie., 1847.

2p. l., iii, xvi, 314 p. 1 l. front. (port.), diagr. 22½ cm.

5. *Gedächtnissrede auf den unsterblich-verdienten Domherrn in Frauenberg, Nicolaus Coppernicus,* als den Erfinder des wahren Weltbaues, welche . . . in der Universitätsbibliothek zu Leipzig, im Maymonate des 1743 Jahres, und also zweihunderd Jahre nach seinem Tode, gehalten worden von Johann Christoph Gottscheden . . . Leipzig, B. C. Breitkopf, 1743.

48 p. 20 cm.

6. *Nicolaus Coppernicus,* von Leopold Prowe. Erster-zweiter Band. Berlin, Weidmann'sche Buchhandlung, 1883-1884.

2 vol. in 3 fronts. (v. 1-2) plates, fold. map v facsims. 24 cm.

7. *Monumenta Copernicana.* Festausgabe zum 19 Februar, 1873, von Leopold Prowe, Berlin, Weidmann'sche Buchhandlung, 1873.

viii, 164 p. 24 cm.

Contents: Aus dem werke *De revolutionibus orbium coelestium.*—Gutachten und Denkschriften. — Übersetzungen aus dem griechischen.— Briefe.

Imperfect: p. 77-164 lacking.

8. *Beiträge zur Beantwortung der Frage nach der Nationalität des Nicolaus Copernicus,* von Kazimierz Römer. Breslau, Priebatch, 1872.

iv, 212 p. 1 l. 22½ cm.

9. *Di Niccolo Copernico astronomo polacco;* ragionamento del cav. Giovanni Sniadecki . . . tradotto della lingua pollacca nell' italiana dal dottore Bernardo Zaydler . . . con aggiunte. [Fiesole] Polographia fiesolana, 1830.

2 p. l., [iii]-iv p., 1 l., 192 p. front. (port.) 23 cm.

10. *Mikuláš Kopernik.* Na oslavu 400 leté památky jeho narození, sepsal dr. F. J. Studnicka . . . S péti drévorytinami. v Praze, Tiskem dra. E. Grégra, nakladem "Jednoty ceskych mathematiku," 1873.

2 p. l., 56 p. front. (port.) diagrs. 21 cm.

11. Kopernikijana Czyli materyały do pism i życia Mikołaja Kopernika [Ignacy Polkowski] . . . Gniezno, Drukiem J. B. Langiego, 1873-85, 3v.

U. M. Lacks v. 3.

General References

1. *Absolvtissimae orbium coelestivm hypotyposes qvas planetarum theoricas vocant*: congruentes cum tabulis Alphonsinis & Copernici, seu etiam

tabulis Prutenticis Opus . . . quo ea quæ ad astronomiam percipiendam necessaria sunt, euidentissimè explicantur, planetrum etiam motus qui quale sue sint quibusque afficiantur passionibus eruditè traditur: omnia in gratiam studiosæ iuuentutis in lucem edita. Coloniæ Agrippinæ, ex officina Petri Horst, M.D.LXXIII.

8 p. l., 354 (i.e. 534) p., 4 l. illus. (diagrs.) 18 cm.

2. *Novae coelestivm orbivm theoricae congruentes cum observationibus N. Copernici.* Auctore Io. Antonio Magino . . . Venetiis, ex officina D. Zenarij, 1589.

15 p. l., 2-115 numb. l illus. diagrs. 24 cm.

3. Prodromus dissertationvm cosmographicarvm, continens mysterivm cosmographicvm de admirabili proportione orbivm coelestivm, deqve cavsis coelorum numeri, magnitudinis, motuumque periodicorum genuinis & proprijs, demonstratvm, per qvinqve regularis corpora geometrica, a M. Ioanne Keplero . . . Addita est erudita Narratio M. Georgii Ioachimi Rhetici, *de libris reuolutionum, atque admirandis de numero, ordine, & distantijs sphaerarum mundi hypothesibus, excellentissimi mathematici totiusque astronomiae restauratoris d. Nicolai Copernici.* Tvbingæ, excudebat Georgius Gruppenbachius, anno MDXCVI.

1 p. l., 181 p. illus., v fold., diagrs. 20½ x 16 cm.

4. *Epitome astronomicae copernicanae* usitatâ formâ quæstionum & responsionum conscripta, inq; vii libros digesta, quorum tres hi priores sunt de doctrina sphæricâ. Habes, amice lector, has prima parte, præter physicam accuratam explicationem motus terræ diurni, ortinque ex eo circulorum sphæræ, totam doctrinam sphæricam nova & concinniori methodo auctiorem, additis exemplis omni generis Computationum Astronomicarum & Geographicarum, quæ integrarum præceptionum vim sunt complexa. Avthore Joanne Kepplero . . . Lentijs ad Danubium, excudebat Johannes Plancus, anno MDCXVIII.

14 p. l., 932 (i.e. 922) p. 8 l. ill., fold., tab., diagrs. 15½ cm.

5. *Dialogo* di Galileo Galilei Linceo matematico sopraordinario dello stvdio di Pisa. E filosofo, e matematico primario del serenissimo gr. dvca di Toscana. Doue me i congressi di quattro giornate si discorre sopra i due massimi sistemi del mondo Tolemaico, e Copernicano; proponendo indeterminatamente le ragione filosofische, e naturali tanto per l'vna, quanto per l'altra parte . . . Fiorenze, Per Gio: Batista Landini, 1632.

5 p. l., 458, [32] p. diagrs. 22½ x 17 cm.

OTHER EDITIONS

(Second Impression) Firenza [Napoli] 1710.

6 p. l., 458 [30] p., 1 l., 83 (i.e. 81) p. diagrs. 30 cm.

Padova, G. Manfrè, 1744.

4 p. l., 242, [1] p. front. (port.) diagrs. 25 cm.

In Livorno, Coi tipi di F. Vigo, 1874.

xxxxiv, 508 p., 1 l. illus. diagrs. 19½ cm.

6. *Novvelle theorie des planetes,* Conforme aux obseruations de Ptolemée, Copernic, Tycho, Lansberge, & autres excellens astronomes, tant anciens que modernes. Avec les tables Richeliennes et Parisiennes, exactment calculées . . . par N. Dvrret . . . A Paris, chez. G. Alliot, 1635.

9 p. l., 80, 144, 64 p. incl. tables, diagrs. 22½ x 16½ cm.

7. *Systema cosmicvm* authore Galilaeo Gallilaei . . . : in que qvatvor dialogia, de duobus maxime mundi systematibus, Ptolemaico & Copernicano, vitriusq; rationibus philosophicis ac naturalibus indefinite propositis, disseritur. Ex italica lingua latine consuersum. Accessit appendix gemina, qua SS. Scripturae dicta cum terrae mobilitate conciliantur . . . Augustae Treboc[corum] Strassburg impensis Elzeviriorum, typis Davidis Havtii, 1635.

8 p. l., 495 p., 12 l., incl. illus., port. 21 x 16½ cm.

Other Editions

Londoni, apud Thomas Dicas, 1663.

11 p. l., 704 p., 12 l., incl. illus. (diagrs.) 17½ cm.

Lugduni Batavorum, apud Fredericum Haaring et Daviden Severinum, bibliopolas, 1699.

2 v. in 1 ([v. 1]: 7 p. l., 494, [26] p.; v. 2: 3 p. l., 826 (i.e. 282), [4] p. front. (port.), illus., diagrs. 21 cm.

8. Antonii Deusingii . . . *De vero systemate mundi dissertatio mathematica,* quâ Copernici systema mundi reformatur: sublatis interim infinitis penè orbibus, quibus in systemate Ptolemaico humana mens distrahitur. Amstelodami, apud Ludovicum Elzevrium, M.D.CLII.

4 p. l., 137 p. diagrs. 19½ cm.

9. *Institvtio astronomica,* de usu globorum & sphaerarum coelestium ac terrestrium: duabus partibus adornata, una secundum hypothesin Ptolemæi, per terram quiessentem. Altera, juxta mentem N. Copernici, per terram mobilem. Concinnata secundum globos atque sphæras, pro-ut inventi prostant apud Iachobum Colom. Amstelodamii, typpis ac impensis Iacobi Colom, bibliopolæ, anno 1646.

246 p. illus. diagrs. 16½ cm.

10. Petri Gassendi *Institutio astronomica,* juxta hypotheses tam veterum quam recentorum. Cui accesserunt, Galileo Galilei Nuntius sidereus, et Johannis Kepleri Dioptrice. Secunda editio priori correctior. Londoni, typis Jacobi Flesher, 1653.

8 p. l., 199, 173 p. illus., 4 pl., diagrs. 18½ cm.

Institutio astronomica juxta hypotheses tam veterum quam Copernici & Tychonis; dictata Parisiis a Petro Gassendi . . . Accedunt ejusdem varij tractatus astronomici . . . Editio ultima paulò ante mortem auctoris recognita, aucta & amendata. Amstelaedámi, apud Janssonia-Waesbergios, 1680.

4 p. l., 309, [7] p. illus., diagrs. 20 x 16 cm.

Abregé de la philosophie de Mr. Gassendi. Seconde partie, contenant *L'institution astronomique.* Les systemes de Ptolomée, de Copernic, & de Tychocieux & autres. Et la refutation de l'astrologie judiciaire. Par F. Bernier . . . Paris, Chez Estienne Michallet, 1675.

3 p. l., 280 p. illus., diagrs. 23 cm.

11. *Atlas coelestis* in quo mundus spectabilis et in eodem stellarum omnium phecnomena in notabilia . . . secundum Nic. Copernici et ex parte Tychonis de Brahe hipothesin. Nostri intuitu, specialiter, respectu vero ad apparentias planetarum indagatu possibiles ex planetis primariis, et e luna habito, generaliter e celeberrimorum astronomorum observationibus graphice de scripta exhibenter a Joh. Gabriele Doppelmaiero . . . Norimbergae, Heredi Hommannianorum, 1742.

2 l., front., 30 double pl. 54 x 34 cm.

12. *Astronomia per Nicolaum Copernicum instaurata religionis et pietatis christianae per Martinum Lutherum ad Scripturae Sacrae normam repurgata egregia adjutrix.* Commentatio astronomico-theologica, quam s. v. theologorum ordini in Academica lipsiensi pro summis in theologia honoribus inter sacra sæcularia traditæ ante trecentos annos Augustanæ confessionis ipsi oblatis exhibuit Gottlob Laberecht Schulze . . . Budissæ, ex officina E. G. Monsii, 1830.

xii, 71 p. 21½ cm.

13 . . . *Scritti sulla storia della astronomia antica* . . . Bologna, N, Zanichelli [1925-]. Parte Prima.

Contains the historical researches of Giovanni Schiaparelli (1835-1910). Section IX: *I Precursori di Copernico nell' Antichità.* Recerche Storiche lette al Reale Istituto Lombardo nell' adunanza del 20 Febbraio 1873, in occasione del 400 anniversario della nascita di Copernico.

Die vorläufer des Copernicus im alterthum. Historische untersuchungen von G. V. Schiaparelli . . . Unter Mitwirkung des Verfassers ins deutsche Übertragen von Maximilian Curtze . . . Leipzig, Quandt & Handel, 1876.

viii, 109, [i] p. 22 cm.

14. *Reliquiae Copernicanae.* Nach den Originalen in der Universität Bibliothek zu Upsala herausgeben von Maximilian Curtze. Leipzig, B. G. Teubner, 1875.

pp. iv, 66+ Plate of diagrs. 24 cm.

15. *Copernico e le vicende del sistema copernicana in Italia* nella seconda metà del secolo XVI e nella prima del XVII con documenti inediti intorno a Giordano Bruno e Galilleo Galilei. Discorso letto nella R. Università di Roma in occasione della ricorrenza del IV centenario di Nicolló Copernico, dal professore Domenico Berti . . . Roma, Tipographia G. B. Paravia e. c., 1876.

255 p. 20 cm.

16. *Refutation du système de Copernic* exposé en dix-sept lettres qui ont été adressées à feu M. Le Verrier. Trois réponses de l'astronome éclairé. Le tout accompagné de notes et de figures explicatives, par Pierre Sindico, peintre. Avignon, Sequin frères; Paris, A. Lemerre, 1878.

3 p.l., 295 p. incl. tables xii diagrs. 22 cm.

17. *Copernicus-verein für Wissenschaft und Kunst zu Thorn.* Mitteilungen des Copernicus-verein für Wissenschaft und Kunst zu Thorn. Leipzig, 1878; Thorn, 1880.

v. in illus., facsim., diagrs. 23-29 cm.

18. *Copernicus, an international journal of astronomy.* Edited by Ralph Copeland . . . and J. L. E. Dreyer; vol. i-iii. Peppmüller, 1881-1884.

19. *L'astronomie et ses fondateurs.* Copernic et la découverte du système du monde par Camille Flammarion. Paris, Marpon & Flammarion, [1891].

253 p. incl. front. (port.) 16½ cm.

20. *Galilei und sein Kampf für die copernicanische Lehre,* von Emile Wohlwill . . . Hamburg und Leipzig, L. Voss, 1907-26.

2 v. front. (port.) pl. (v. 2) 24 cm. vol. 1 at UM.

21. *The law of Oresme, Copernicus, and Gresham*: a paper read before the American Philosophical Society, April 23, 1908, by Thomas Willing Balch . . . Philadelphia, Allen, Lane and Scott, 1908.

3 p. l., 21 p. 27½ cm.

"Reprinted from the Proceedings of the American Philosophical Society, volume XLVII, 1908."

22. *Stimmen [aus Maria-Laach] der Zeit;* katholische Monatschrift für das Geistesleben der Gegenwart. 1.—bd., Juli, 1871—Freiburg im Breisgau [etc.], Herder, 1871-19.

v illus., plates, maps, plans, tables 24 cm.

SUPPLEMENT NO. 101

Galileo Galilei und das kopernikanische Weltsystem, von Adolf Müller, S.J., Freiburg im Breisgau, St. Louis, Mo., etc. Herder, 1909.

xii, 184 p., front. (port.) 24 cm.

23. *Von Kopernicus bis Einstein;* der Wandel unseres Weltbildes, von dr. Hans Reichenbach . . . Berlin, Ullstein [1927].

121 p. incl. illus., diagrs. 17½ cm.

From Kopernicus to Einstein, by Hans Reichenbach, translated by Ralph B. Winn., New York Philosophical Library, Alliance Book Corp., 1942.

123 p. incl. iilus., diagrs. 24 cm.

24. *The Defense of Galileo of Thomas Campenella* (1568-1639); for the first time translated and edited, with introduction and notes by Grant

McColley. Northampton, Mass., Department of History of Smith College [1937].

xliv, 93 p. 23 cm.

25. Dialog über die beiden hauptsächlichsten Weltsysteme: das Ptolemaische und das Kopernikanische, von Galileo Galilei. Aus dem Italienischen übersetzt und erlaütert von Emil Strauss . . . Leipzig, B. G. Teubner, 1891.

lxxix p., 2 l., 586 p. diagrs. 25 cm.

Contains reproduction of t.-p. and illustrated half title of first Italian edition, Florence, 1632.

26. Astronomia nova αιτιολογητος, sev Physica coelestis, tradita commentariis de motibvs stellæ Martis, ex observationibus G. V. Tychonis Brahe: jussu & sumptibus Rvdolphi II. Romanorvm imperatoris etc.: plurium annorum pertinaci studio elaborata Pragæ, Joanne Keplero, 1609.

[40], 337 p., ill., i table F^4

Works Contributing or Continuing the Copernican Theories

Brudzewo, Albertus de (1446?-1495)

This writer is particularly important because he taught Astronomy to Copernicus.

Commentariolum super Theoricas novas planetarum, Georgii Purbachii in Studio generali cracoviensi mag. Albertum de Brudzewo diligenter corrogatum A.D. MCCCCLXXXII. Post editionem principem mediolanensem a MCCCCXCV ad fidem codicum praestantissimorum denuo edendum curavit Ludovicus Antonius Birkenmajer. Cracoviæ, typis et sumptibus Universitatis Jagellonicae provisore Josepho Filipowski, 1900.

lvi 168 [1] p. diagrs. 24 cm.

Müller, Johannes; Regiomontanus (1436-1476)

Regiomontanus was the greatest of the predecessors of Copernicus.

Calendarium. Venice, [E. Ratdolt] 1483.

26 l. diagrs. 20.8 cm.

Doctissimi viri et mathematicarum disciplinarum eximij professoris Ioannis de Regio monte *De triangvlis omnimodis libri quinqve;* quibus explicanturres necessariae cognitu, uolentibus ad scientiarum astronomicarum perfectionem deuenire: quae cum nusquã alibi hoc tempore expositae habeantur, frustra sine harum instructione ad illam quisquam aspirarit. Accesserunt huc in calce pleraque d. Nicolai Cusani de quadratura circuli, déque recti ac curui commensuratione: itemq Io. de monte Regio eadam de re ἐλεγκτχα, hactenus a nemine publicata. Omnia recens in lucem edita, fide & diligentia singulari Norimbergae in aedibus Io. Petrei. Anno Christi M.D.XXXIII.

137 p. illus. (diagrs.) 30½ cm.

Ioannis Regiomontanii . . . *de triangvlis planis et sphaericis libri quinque,*

una cum tabulis sinuum . . . Qvam mvltiplicem vsvm haec triangvlorum, doctrina omnibus . . . adferat . . . qui sana rerum intelligentia sunt instructi, in sequenti opere, quod complecitur . . . Astronomicorum & Geometricorum problematum descriptionem [autore D. Santbech] . . . deprehendere poterunt. Omnia . . . edita . . . per Danielem Santbech. Basileæ, [1561].

[2], 146 p. 19 fol. of tables * 4 a-o,6 p8 32½ x 21½ cm.

Dedicatory epistle by J. Schonerus, p. 130.

"Tractatvs Georgii Pevrbachii super propositiones de sinubus & chordis:" p. 131-139.

Recorde, Robert (1510?-1558)

The Castle of Knowledge . . . London, R Wolfe, 1556.

8 p. l., 286 p. 1 l. incl. illus., tables, diagrs. 27 cm.

"Containing the explication of the sphere bothe celestial and materiall."

This work gained great popularity when it influenced the theories of Kepler.

Witelo, 13th cent. (Polish physicist and philosopher)

Vitellionis mathematici doctissimi περὶ ὀπτικῆς, id est natura, ratione, & proiectione radiorum uisus, luminum, colorum, atque formarum, quam uulgo perspectium uocant libri x . . . Nunc primum opera mathematicorum praestantias. dd. Georgij Tanstetter & Petri Apiani in lucem aediti. Norimbergae, apud I. Petreium, 1535.

4 p. l:. 297 numb. l. 1 illus., diagrs. 31½ cm.

Reprinted under the same title in 1551.

Third edition by Friederick Risner (d. 1580): *Opticae libris decem,* instaurati atque aucti infinitisque erroribus quibus antea scatebant expurgati (Basel, 1572; appended to Risner's Latin edition of Alhazen).

Alhazen fl. 1030

Opticae Thesavrvs, Alhazeni Arabis libri septem, nuncprimum editi. Eivsdem liber de crepvscvlis & nubium ascensionibus item Vitellonis Thvringopolem libri x. Omnes instaurati, figuris illustrati & aucti, adiectis etiam in Alhazenum comentarijs à Frederico Risnero, Basileæ per Episcopios M.D. LXXII.

3 p. l., 288 p. illus., diagrs. 34 cm.

Gemma, Reinerus, Frisius, 1508-1555

Gemmae Frisius . . . *De radio astronomico & geometrico liber.* In quo multa quae ad geographiam, opticam & astronomiam vtilissima sunt, demonstrantur . . . Adiunximus breuem tractationem Ivannis Spangegergij & Sebastiani Munsteri de simpliciore radio quem baculu Iacob vulgus nominat. Lvtetiæ, apud Gulielmum Cauellat, 1558.

87 numb. l., [2] p. incl. tables, diagrs. 18 cm.

Works of an Anticopernican Nature

These works show the prejudice that was entertained against the Copernican theory.

Polacco, Giorgio

Anticopernicvs catholicvs, sev. *De terrae statione,* et de solis motv, contra systema Copernicanum, catholicae assertiones. Avctore Giorgio Polacco . . . Venetiis apud Guerilios, 1644.

4 p. l., 107 p. illus. 21½ cm.

Riccioli, Giovanni Battista, 1598-1671

Almagestvm novvo astronomiam veterem novamque complectens observationibvs aliorvm, et propriis nouisque theorematibus, problematibus, ac tabulis promotam, in tres tomos distribvtam . . . Avctore P. Ioanne Baptista Ricciolo Societatis Iesu Ferrariensi . . . Bononiæ, ex typographia haeredes Victorij Benatij, 1651.

1 v. in 2 engr. fronts., illus., 2 double pl., tables, diagrs. 36 cm.

Argomento fisicomattematico del padre Gio: Battista Riccioli, . . . contro il moto divrno della terra, confermato di nuouo con l'occasione della Reposta alle Considerazioni sopra la forza del detto argomento, etc., fatte dal M. R. Fr. Stefano degli Angeli, e Fratelli de' Manolessi, 1668.

[8], 93, [3] p. diagrs. 23 cm.

Isolated Articles Appearing in Various Periodicals

1. Curtze, Maximilian, "Hat Copernicus die Einleitung in sein Werk de Revolutionibus selbst geschrieben oder nicht?" *Zeitschrift für Mathematik und Physik,* 20:60-62, 1875.

2. Daubrée, Gabriel Auguste, "Copernicus et les découvertes géographiques de son temps," *Journal des Savants,* 750-758, 1895.

3. Hagen, Johann Georg, "Das Coppernicanische Sonnensystem," *Stimmen aus Maria Laach,* 47:49-54; 181-190; 287-293, 1894.

4. McColley, Grant, "The Universe of De Revolutionibus," *Isis,* 30:452-472, 1939.

5. McColley, Grant, "An early allusion to the Copernican theory," *Journal of the History of Ideas,* 3:355-357, 1942.

6. Rosen, Edward, "The Ramus-Rheticus Correspondence," *Journal of the History of Ideas,* 1:363-368, 1940.

7. Sprenger, Aloys, "The Copernican system of astronomy among the Arabs," *Journal of the Asiatic Society of Bengal,* 25:187, 1856.

8. Steinschneider, Moritz, "Copernicus, nach dem Urtheile des David Gans, eines jüdischen Astronomen, der mit Tycho de Brahe in Verbindung stand," *Zeitschrift für Mathematik und Physik,* 16:252-253, 1871.

9. Zilsel, Edgar, "Copernicus and Mechanics," *Journal of the History of Ideas,* 1:113-118, 1940.

NICOLAS COPERNICUS[1]

By PROFESSOR ALEXANDRE KOYRÉ
University of Paris, Ecole Libre Des Hautes Etudes

The year 1543, the year of the publication of the *De Revolutionibus orbium Caelestium* and of the death of its author, Nicolas Copernicus, marks an important date in the history of human thought.

One is tempted to consider it as that of the "end of the middle ages and the beginning of the modern times," because, much more than the conquest of Constantinople by the Turks, or the discovery of America by Christopher Columbus, it marks the end of a world and the beginning of a new one.

Yet, perhaps this would still be a misvaluation: the cut made by Copernicus does not mark the end of the Middle Ages alone. It marks the end of a period which embraces both the Middle Ages and Antiquity; for it is with Copernicus, and only since then, that man no longer stands in the center of the World, that the Cosmos does not revolve around him.[2]

* * *

It is rather difficult for us, to-day, fully to understand, to realize and to appreciate in their overwhelming greatness the intellectual effort, the daring and the moral courage embodied in the work of Copernicus. In order to be able to do so, we would have to forget the spiritual development of a couple of centuries; we would have to force ourselves to go back to the naive and unquestioned certitude with which common sense accepts the immediate evidence of the immobility of the earth and of the motion of the skies.

Even that would not be sufficient. To this evidence we should be able to add the influence of a threefold teaching: scientific, philosophical, theological. A threefold tradition, a threefold authority of

[1] The following paper was read at the Copernicus celebration in the Polish Institute of Arts and Science on May 3, 1943.

[2] The heliocentric system, as everything or nearly everything else, originates, of course, in the Greek thought (cf. Sir Thomas L. Heath, *Aristarchos of Samos,* London, 1913, and Pierre Duhem, *Le Système du Monde,* vol. I and II, Paris, 1913-17). Yet, it never received recognition (a) because it never was developed into a real, workable astronomic theory, and (b) because it could never meet the physical objections against the motion of the Earth. On the importance of these cf. A. Koyré, *Etudes Galiléennes,* III, Paris, 1940, and "Galileo and the Scientific revolution of the XVIIth century," *Philosophical Review,* 1943.

calculus, of reasoning, of revelation.[3] Then, but only then, would we be able to render to ourselves an account of the incomparable boldness of the Copernican thought, which tore the Earth from its foundations and hurled it in the skies.

* * *

If it is difficult for us—or even impossible otherwise than in imagination—to realize the liberating effort of Copernicus, it is just as difficult to grasp the depth and the strangeness of the impression that the reading of his work could not fail to make on men of his time; the destruction of a world that all, science, philosophy, religion represented as centered upon man and created for him; the crumbling of the hierarchical order which, opposing the sublunar world and the skies, united them in and through this opposition itself . . .

The impact was too great. The new world conception seemed too crazy to be taken seriously. Besides, the book, as a whole, was much too difficult for readers not trained in mathematics and astronomy.[4]

As Copernicus expressed it himself: *mathemata mathematicis scribuntur.* Let us leave it to mathematicians. It's only a new hypothesis; new and old at the same time. A scheme for calculation, with no more real importance than those of various astronomers till then.[5] This is what, in spite of the *Narratio Prima* of Joachim Rheticus, and thanks to Osiander's clever introductory "letter to the reader" prefixed to the work of Copernicus, was commonly thought for about half a century or so. The Church didn't stir; Melanchton (and Luther) alone realized at once the bearing and the meaning of the work.[6]

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[3] The authority of the Bible weighed heavily against the heliocentric system and prevented its universal recognition until the XVIIIth century. But in the times of Copernicus — and until Galileo and Descartes — the opposition of the Aristotelian philosophy and physics was at least as potent.

[4] Joachim Rheticus, the only disciple of Copernicus (cf. *infra, p.* 717) insists therefore that "the staff of the astronomer is mathematics, or geometry," *Narratio Prima,* p. 164 in E. Rosen, *Three Copernican treatises,* New York, 1938.

[5] cf. *infra* p. 721.

[6] Apelt, in his old but still valuable book, *Die Reformation der Sternkunde,* Jena, 1842, p. 166, writes: "The new doctrine of the catholic canon, an essentially German plant, just as protestantism itself, has been conserved and worked out chiefly by protestants. . . . The destiny of the new astronomy was, in some sense, bound with the destinies of protestantism." I quote this phrase in order to point out what nonsense can be written—even by a good historian—under the damaging and blinding

It is only later, much later, when it became obvious that the work of Copernicus was not a matter for "mathematicians" alone; when it became visible that the blow it dealt to the geocentrical and anthropo-centrical world was a mortal one; when, in the works of Giordano Bruno, it had time to develop some of its metaphysical and religious implications—that the old world reacted. A twofold reaction: the condemnation of Copernicus and of Galileo, the attempt to suppress the new world conception; the *Pensées* of Pascal, an endeavour to reply.

* * *

It would be of deep, of priceless value for the history and the phenomenology of human thought to be able to follow the development, to reconstruct and to reconstitute the various steps, of Copernicus' thought. Alas, I must at once confess: this is an impossible task. Copernicus left no intellectual autobiography; his biography by his pupil Joachim Rheticus, is lost; the few indications he gives us in his proud and beautiful letter to Pope Paul the Third, which constitutes the foreword to *De Revolutionibus,* are very scant and, moreover, not very reliable. As for his *opus* itself, he presents it to us—even in the *Commentariolus*—in a state of perfection that is the despair of the historian.

Still, if we have to abandon the hope of writing the history of Copernican thought, we must, at least, make an attempt at grasping it in its historical meaning and truth . . . to bring it nearer to our own thinking while avoiding every modernization of it. And, in order to do so, we must try *not* to see in Copernicus the forerunner of Galileo and of Kepler and *not* to interpret him in the light of later developments.[7]

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influence of national and religious prejudice. As a matter of fact, though Rheticus and Kepler were protestants, protestantism had just as much to do with the new astronomy as Germanism, that is, *absolutely nothing.* Indeed, while Catholic authorities remained quiet until 1616, Luther condemned Copernicus as early as 1541 (cf. *Tischreden,* vol. IV, p. 575) and Melanchton, who, in a letter to Bernardus Mithobius (Oct. 16, 1541) declared that the attempt of Copernicus (whom he called *Sarmaticus Astronomus*) "to move the Earth and to hold still the Sun" was absurd, opposed it in his *Physics* (Wittenberg, 1552, p. 60 sq. 99 sq.) and was followed by nearly all the protestant divines. Thus the Physics of Comenius, reprinted through the whole of the XVIIth century, violently opposed the new astronomy.

[7] The conception of the "forerunner" is a very dangerous one. Though it is true, that ideas have a quasi autonomous development, *i.e.* that ideas born in one mind mature and bring fruit in another; though it is certain that, for later generations, the older ones are interesting chiefly as their "forerunners" and "ancestros," it is—or should be—nevertheless obvious that nobody ever had, nor could have had, considered himself as a "forerunner." He could hope, of course, that later generations will solve problems that he had to leave unsolved. But that is quite another thing.

This is a very important task,—a task which, in my opinion, has been rather neglected until now. As a matter of fact, whereas we have a number of good expositions of the astronomy of Copernicus,[8] and whereas treasures of ingenuity and erudition were spent on the problem of his biography,[9] or better to say, whereas innumerable efforts were spent in order to prove Copernicus to be a Pole or a German (an interesting but still a subordinate problem[10]), the study of his physics has seldom been seriously attempted. And yet, as Schiaparelli has already stated with his habitual insight,[11] the Copernican problem was above all a problem of physics and of cosmology.

* * *

Nicolas Kopernik was born at Toruń, in Polish Prussia (Pomorze), on February 19, 1473. His father, whose name too, was Nicolaus, was a burgher of Kraków, his mother Barbara Watzelrode, a daughter of an old patrician Toruń family.

As both of them died when Copernicus was 12 years old, he, as well as his brother Andreas, was adopted by his uncle, Lucas Watzelrode, his mother's brother, who later (in 1489) became prince-bishop of Warmia. Was Copernicus a Pole or a German? I must confess that, to me, this question, or rather the importance given to it, appears somewhat anachronistic. Copernicus lived in a time which, with some exceptions,[12] was not yet poisoned by nationalism and nationalistic passions, which still enjoyed the blessings of a common culture and of a common scientific language.[13] Besides, he lived in an Empire (medieval Poland was not a national state,

[8] Cf. J. L. Dreyer, *History of the Planetary Systems,* Cambridge, 1906, A. Armitage, *Copernicus,* London, 1938.

[9] Thus the great work of Prowe, *Nicolaus Copernicus,* Berlin, 1813-4 deals with the biography of Copernicus, the history of his time, but neglects the physical and philosophical problems of the Copernican Revolution.

[10] An exception are, of course, the magnificent works of Ludwik A. Birkenmajer; *Mikołaj Kopernik—Studya nad Pracami Kopernika oraz Materyały Biograficzne, Część* 1, Kraków, 1900; *Mikołaj Kopernik—Jako Uczony i Twórca, Kraków,* 1923, and *Stromata Coperniciana, Kraków,* 1924.

[11] Cf. G. V. Schiaparelli, *I Precursori del Copernico nell'antichità,* Milano, 1873.

[12] National opposition and national strife is not quite a new phenomenon; we encounter it, even during the Middle Ages, in Spain, in the Balkans, in Asia Minor, etc. It is especially strong where it coincides with a religious opposition, as between Christians and Moslems, or Orthodox and Catholics; sometimes it takes places even without religious background, so in Bohemia between Czechs and Germans. Yet these cases are rather infrequent.

[13] I would like to point out that Copernicus—and there was nothing unusual in his case—began his studies in Kraków, and continued them in Bologna, Ferrara and Padova.

but an Empire), whose multi-national subjects, united by and through common allegiance to the State (*Res Publica*) happily ignored minority problems and rights—(which, by the way they fully enjoyed), frequently intermarried and, generally speaking, got along pretty well.

If we were able to put to Copernicus himself the question, "are you a German or a Pole?" he certainly would not have understood us, and probably would have answered that, of course he was *Polonus,* meaning that he was a burgher of Toruń, son of a burgher of Kraków, a good Catholic, a canon of Frauenburg in Warmia, a faithful subject of the Kingdom of Poland, and a bitter enemy of the Teutonic Order. That, for his scientific work as well as for intercourse with his peers, he used the language of science and culture i.e. latin; but that, of course, when he had to deal with common people, he used their speech, Polish in Kraków and German in Frauenburg.

If we would insist, and try to make him understand that we are looking for something different, that we intend to explain his work and his genius by his "nation" or his "race," he probably would have become cross and would have informed us that the idea of explaining the individual by the specific or the general is perfectly stupid, that such a procedure is only valid when and where we have to explain general (or specific) features of individual beings; that it may be applied with good success in realms of nature which lack of true individuality (e.g. minerals, plants, animals), but not to man, who, as a spiritual substance, cannot be explained by features and factors pertaining to his material being. I am afraid that, if we would allow him to become somewhat anachronistic (as ourselves), he would add that Taine's theory according to which a man or a work of genius can be "explained" by "race, environment, and historical moment" could only be invented and shared by barbarians utterly devoid of philosophical training.

Yet, as we cannot avoid being anachronistic, I will add that, as a matter of fact, we have no reason whatever to suppose that Copernicus was anything but a Pole. Besides, until the middle of the XIXth century, nobody ever doubted it. And it is only since the growing nationalism of European and, especially, of German thought and historiography, that some German historians, ready to serve the aims of German imperialism, have made a claim on Copernicus. A

claim just as well founded as analogous claims with regard to Leonardo da Vinci, Dante, Michel Angelo and so many others.

* * *

In 1491 we find Copernicus in the University of Kraków. We need not speculate about the reasons which guided his choice: the University of Kraków enjoyed a very high reputation at that time.[14] It was, as a matter of fact, since the downfall of Prague, the most important of the Eastern Universities, a famous place of learning and humanistic culture. Besides, Kraków was not far away from Toruń, and it is safe to assume that Copernicus still had relatives in the birthplace of his father.

We lack information about the course of studies pursued by Copernicus in Kraków. Yet—though it is obvious that he made a thorough study of astronomy there—we have no reason to doubt that he followed the habitual curriculum of the Faculty of Arts, including dialectics and philosophy. Copernicus, as a matter of fact, is not a narrow specialist, an "astronomer" as Peurbach or Regiomontanus, but a man deeply imbued with all the rich and complex culture of his time, an artist, a classical scholar, a scientist, a man of action: a *humanist* in the best sense of this word.

Because of his astronomical studies, the biographers of Copernicus admit that he enjoyed, quite particularly, the teaching of Albert of Brudzewo (Brudzewski). Yet, Albert of Brudzewo, who indeed, for a long time taught astronomy with great success and distinction (in 1482 he wrote for his pupils a Commentary on the *Theorica Nova Planetarum* by Peurbach)[15] was by no means the only Professor of astronomy in the University of Kraków. On the contrary, there were fourteen of them. Besides, since 1490, Albert of Brudzewo did not teach astronomy any more, but lectured on Aristotle's *De Caelo.*

Albert of Brudzewo left Kraków in 1494 and the biographers of Copernicus admit usually that Copernicus left it too about the same time.

This is as it may be; in any case, in 1496 he went to Italy, to study law at the University of Bologna. On January 6, 1497 we find his name inscribed on the roll of the *Natio Germanorum* of the Uni-

[14] Mathematical and astronomical studies were quite particularly flourishing in Kraków.

[15] This commentary, the first of the numerous commentaries of this very popular textbook, was printed in 1495 in Milano.

versity. Which, by the way, does *not* imply that Copernicus was, or even considered himself, as a German. "Nationes" of a mediaeval university have nothing to do with nations in the modern sense of the word[16]; the German Nation (in Bologna), on the rolls of which there is quite a lot of non-German names, was the "smart" one and, as such, was usually joined by young Polish noblemen. Copernicus, indeed, was not a nobleman but a commoner. Yet as the nephew of a bishop, and of a high ranking one at that, he could not decently join a socially less prominent "nation."

Copernicus stayed in Bologna for about three years. He studied astronomy, of course, though he seems already to have known enough of it to be received by the famous astronomer, Domenico Maria Navarra, *non tam discipulus quam adjutor et testis observationum;* but, at the same time, he studied a lot of other things: law, medicine, philosophy; he learned Greek; he read Plato . . . Once more, we must never forget that Copernicus is not an "astronomer" but one of the most all-round minds of his time.

In 1500 he went to Rome (1500 was the year of the Jubilee which attracted thousands of pilgrims to the capital of Christendom), where, as his pupil Rheticus informs us, he gave a course of lectures on mathematics; Rheticus, unfortunately, does not say what specifically he lectured about.

It seems that Copernicus did not crave going home. Yet it became necessary to do so, in order to take possession of a canonry at the cathedral church of Frauenburg, to which he had been elected, owing to the protection of his uncle, Lucas Watzelrode.

In 1501 he is back in Poland; but not for a long time. After his formal installation in the canonry he asks for leave, and, having obtained it, returns to Italy. This time he goes to Padova, famous for its schools of medicine and law. In 1503 he goes to Ferrara, but does not stay there and, after being received *Doctor utriusque iuris* (on May 31st), returns to Padova.

Copernicus seemed to be well pleased with his life in Italy. Alas, all good things—even, and perhaps particularly, leaves of absences —come to an end. Chapters do not like non-resident members and

[16] The "Nations" of a Medieval University (in the University of Paris there were four "nations" among which we find the *Burgundian* and the *Picardian* "nations") are rather to be compared with modern fraternities, endowed, moreover, with some public functions.

Copernicus, though nephew of the Bishop, had to abide by the rule. In 1506 he rejoins his diocese, never to leave it until his death.

* * *

The life that awaited Copernicus at home was not, as we may be inclined to picture it to ourselves the life of a canon, the quiet and easy life of thought and of prayer. Quite on the contrary, it was a life of action. A mediaeval bishopric, and quite particularly such a one as the bishopric of Warmia, was a political as much as an ecclesiastic institution and had to do with worldly as much as with religious affairs.[17] And Copernicus who, for years, until the death of Lucas Watzelrode, acted as his secretary (and his doctor), entrusted among other things, with the economic administration of the bishopric—we owe to this activity his treaty on money[18] —didn't have much time left for meditation, for study, for calculations . . . So it is only gradually, bit by bit, that his immortal work grew and took shape.

I said: meditation, calculus . . . not observations. We must not think of Copernicus as spending his nights scrutinizing the skies in order to discover some new facts, some new determinations of the positions of the heavenly bodies. Copernicus is not a practical astronomer. He is not Tycho Brahe. He made, of course, some observations; but very few. He gives us some determinations of his own of the positions of the planets. Yet these are neither numerous,[19] nor very important. Perhaps, not at all. The greatness of Copernicus—and I would like to stress that point—consists in his having framed and developed a new theory, not in having provided us with new facts. Indeed, his theory, or better to say, his system, is based entirely on data already available then, chiefly on those of Ptolomy. And, to say the truth, his system—a new interpretation of these old data—at least insofar as we are concerned with calculation of observable phenomena—is no more in accordance with them[20] than that of Ptolomy which it endeavours to replace.

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[17] The bishopric of Warmia was an important political and even military position, and churchmen had even to act as soldiers. Thus, during the war with the Teutonic Order (in 1520) the episcopal city of Olsztyn was beleaguered by the troops of Albert of Hohenzollern and stubbornly and skillfully defended by Copernicus, who, at this occasion, acted as commander in chief.

[18] *De Monetae cudendae ratio,* in 1526.

[19] 27 in all. Cf. Dreyer, *op. cit.* p. 316.

[20] cf. Apelt, *op. cit.* p. 150: "If we ask: what practical advantages did astronomy receive from the theory of Copernicus? we must reply: immediately, none whatsoever. The system of Copernicus, such as it came out from the hands of its author is no more in accordance with the skies than that of Ptolomy."

Those of us who are not very well acquainted with the history of astronomy will, probably, be slightly astonished. And yet it is a fact that, for all practical purposes, the Ptolomaic astronomy gave a most satisfactory account of the observational data. We must never forget (a) that, until Galilei who was the first man to use a (newly discovered) optical instrument—the telescope—to look at the skies, all astronomical observation were made with the naked eye and (b) that, mathematically speaking, the astronomy of Ptolomy is one of the most wonderful achievements of the human mind. As a matter of fact, its device of superposing and of combining of circular motions, of epicycles and excentrics, enables it to represent — though, of course, in a rather cumbrous way—almost any given curve and to establish nearly as well as our modern theory of functions a mathematical relationship between any given datas.

It is only from the point of view of cosmology, that is, only when the astronomer tried to treat his circles and orbs as real objects in real space that he encountered some difficulties; the circles and orbs pertaining to different planets sometimes intersected and embraced each other, which looked rather bad *in et per se,* and moreover, flatly contradicted the Aristotelian cosmology, which (worked out long before Ptolomy) persisted in using spheres and assigned to each planet, and to the whole of its moving mechanism, a definite spherical region of the Universe. That is the reason why, since the revival of Ptolemaic astronomy, and especially in the second half of the XVth century, the opposition between the "philosophers" and the "mathematicians" gave birth (a) to attempts to harmonize the systems of Aristotle and of Ptolomy and (b) to attempts to explain away the whole problem by presenting the mathematical astronomy as a merely mathematical device not concerned with reality.[21]

The central idea of his system seems to have been conceived by Copernicus rather early, perhaps even before he left Italy. In the

[21] This situation is not particular to Copernicus' times. The development of mathematical astronomy by the predecessors of Ptolomy and Ptolomy himself was accompanied by a growing conviction that their geometrical construction did not represent the physical truth, and that astronomy, which seemed not to be able to discover the real causes of the celestial phenomena, i.e. the real motions of the planets, had to abandon this aim, and to content itself with a purely phenomenalistic theory, which would enable the astronomer to σώζειν τὰ φαινόμενα, *salvare apparentias.* The same discussions are to be found in the arabic philosophical and astronomical literature (*e.g.* Averroes flatly denies the physical reality of the circles and spheres of the astronomers), and are well known to scholastics. Cf. Dreyers *History of Planetary Systems,* London, 1906 and of course P. Duhems magnificent *Le Système du monde,* Paris, 1913-1917.

letter-foreword of the *De Revolutionibus* Copernicus says that he kept his work secret not for nine years (as the Pythagoreans prescribed), but four times nine years. Of course that cannot be taken literally, as concerning the book itself, only its main conception. In that case it would mean that "four time nine years" were spent in the elaboration and perfection of the theory. Copernicus understood that it was of no use to formulate a new idea, or even, as it was in his case, to try to revive an old one. He was perfectly aware that, if he had to succeed, he had something quite different to do, something that nobody had done before, i.e. to present a theory of planetary movements, a theory just as complete, and just as workable, enabling prediction and calculation of observable celestial phenomena, as that of Ptolomy or his mediaeval commentators and followers.[22]

We do not know exactly *when* Copernicus completed the elaboration of the *De Revolutionibus*. Certainly not before 1530, perhaps even some years later.

It seems that some time before the final working out of his system, Copernicus wrote, and had circulated among his friends, a short and schematic exposition of the new astronomy, the so-called *Commentariolus* which remained unedited till 1876.[23]

The Commentariolus which, from the point of view of astronomy, that is, of the concrete arrangement of the movements of celestial bodies and orbs, differs somewhat from the *De Revolutionibus,*[24] is very interesting because it reveals to us at least some of the reasons which guided and moved the thought of Copernicus.

Copernicus begins by pointing out that the astronomy of Calippos and Eudoxos[25] did not succeed in explaining the observable and

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[22] In his *Commentariolus* (cf. *infra*) Copernicus writes: "Let no one suppose that I have gratuitously asserted with the Pythagoreans the motion of the Earth; strong proof will be found in my exposition of circles." (p. 59 of E. Rosen's translation, cf. *infra,* n. 23).

[23] *Nicolai Copernici de hypothesibus motuum coelestium a se constitutis Commentariolus.* An excellent English translation, with notes and a very interesting and scholarly introduction was published, in 1939, by M. E. Rosen, cf. *Three Copernican treatises,* New York.

[24] The system of the *Commentariolus* is "concentro-biepicyclic" whereas that of the *De Revolutionibus* is "eccentro-epicyclic." Cf. Aleksander Birkenmajer, "Le premier système héliocentrique imaginé par Nicolas Copernic," in *La Pologne au VIIe Congrès International des Sciences historiques,* Warsaw, 1933.

[25] Calyppos and Eudoxos used only homocentric spheres. Their astronomy formed the basis of the Cosmology of Aristotle.

indubitable variations of the distances between the Planets and the Earth; that the system of Ptolomy, though much more successful concerning this point, failed in respect of another, namely, it did not succeed in presenting the movements of the planets as composed of *uniform* circular motions; and in order to save some kind of uniformity, he was compelled to introduce into his calculations the rather dubious concept of "equant."[26] This proceeding constitutes, from the point of view of Copernicus, a somewhat dishonest device.[27] Consequently, astronomy had to try out something else.

Seven "axioms" or "petitions" (*axiomata vel petitiones*: it is interesting to note this Euclydian and Archimedian terminology) present the chief characteristics of the new system.

The first and foremost of these axioms or petitions states the necessity for building up a system of celestial movements "in which everything would move *uniformly around its proper center,*[28] as the rule of absolute motion requires."

The second states that, "the center of the Earth is not the center of the Universe, but only of gravity and of the lunar sphere."

The third, that "all the spheres revolve about the sun as their mid-point, and therefore the sun is the center of the Universe."

The fourth and the fifth explain that the common motion of the celestial phenomena is due not to the motion of the firmament but to that of the Earth.

The sixth explains that the Sun stands still and that its apparent motion is only the projection of the motion of the Earth; the seventh, that the retrogradation and other peculiarities of the motion of the planets are only apparent, not real motions, and that these appear-

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[26] In order to simplify the system and lessen the accumulation of circles and orbs, Ptolomy let the planets move on their circles with a non-uniform velocity. Yet, in order to preserve some kind of uniformity, he used only motions the angular velocity of which, in respect to some point in the interior of the circle (*not* its center) was uniform. This point was called *punctum aequans.*

[27] It is, probably, the conception of the *equant,* combined with that of excentricity of the orb of the Earth, which led Kepler to his discovery of the ellyptical character of the planetary orbits. Yet, from his point of view, Copernicus was completely right in stating that (*Commentariolus,* p. 1.) "*Valde enim absurdum videbatur coeleste corpus in absolutissima rotunditate non semper aeque moveri. . . .* Yet Ptolomy could not "save the appearances," *Nisi etiam aequantes quosdam circulos imaginarentur . . . qua propter non satis absoluta videbatur huius modi speculatio neque rationali satis concinna.*"

[28] *Commentariolus,* E. Rosen's translation, p. 76.

ances are due to the projection on the firmament of the annual motion of the Earth.

Seven small chapters deal with the threefold movement of the earth; they explain the order of the celestial orbs; they suggest the advantage of referring the movement to the fixed stars, and not, as commonly, to the equinoxial points (just because the latter are not *fixed,* but—though very slowly—shift their positions); they describe the mechanism of the planetary movements (the Moon, the superior planets, Venus, Mercurius, Earth) and give an account of the dimensions of the epicycles and orbs. All that without demonstrations and proofs of any kind, the latter being reserved to the larger work, *majori volumini.*

It seems that Copernicus, though he persistently and obstinately opposed the publication of his work, nevertheless made no secret of his views. The *Commentariolus* seems to have circulated fairly widely. Not only was it known to his immediate friends, but, according to Tiraboschi,[29] it found its way even to Rome, where the Austrian Chancellor Johann Widmanstadt presented it to Pope Clement VII in 1533 and explained to him the principles of the new astronomical system. In Rome neither the Pope, nor anybody else seems to have been very much struck by the new theory. It is possible that the title of the little work with its use of the term *hypothesis*[30] gave the impression that it was only a new, and somewhat extreme, mathematical construction which did not pretend to give a description of the real world. It is possible that this was the interpretation which Widmanstadt gave to the new theory. It is, on the other hand, just as possible that the Pope and the cardinals did not grasp its implications.

In any case, nobody raised any objections whatever. More than that, some three years later, one of the members of the Roman *curia,* the cardinal archbishop of Capua, Nicolas Schonberg, wrote to Copernicus (Nov. 1st, 1536) suggesting to him publication of his discoveries and asked him to order that a copy (for which the Cardinal offered to pay the expenses) be made of his work.

Copernicus did not follow the friendly advice of the Cardinal

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[29] N. Tiraboschi, *Storia della Litteratura Italiana,* Milano, 1824, vol. VII, p. 706, quoted by Dreyer, *op. cit.* p. 317.

[30] The term *hypothesis* as employed by Copernicus is practically equivalent to *theory,* and does not imply the non assertion of its truth. Cf. E. Rosen's *Introduction* to his translation of the *Commentariolus,* New York, 1939.

of Capua. As far as we know, he did not even order the copy Schonberg asked for. In point of fact, the Cardinal of Capua was by no means the first who urged him to publish his work. Quite on the contrary, all his friends, and above all, "his very dear Tiedeman Giese, Bishop of Kulm" had, for a long time, insisted on publication, representing it to Copernicus as his duty toward science and mankind. But Copernicus could not decide. He knew better. He feared *calumniatorum morsus.* And at 60, he obviously valued nothing more than tranquility.

In the year 1539, a young professor of the University of Wittenberg, Joachim Rheticus by name, came to Frauenburg. He had heard about the new theories of Copernicus. He wanted to find out the truth about them.

Well received by Copernicus, he stayed with him for about two years, studying the manuscript of the *De Revolutionibus,* working with the old man whom he always calls his *Dominus Doctor Praeceptor.*

Joachim Rheticus was at once conquered and convinced. Conquered and seduced by the greatness of mind and the charm of Copernicus' personality; convinced and enticed by the beauty of his work. And, in order that the light remaineth not under the bushel, he started a bare couple of months after his arrival, and long before he had completely mastered the new astronomy,[31] to compose a short account of it which he sent to his master, Johannes Schöner. The latter, just as quickly, had it printed.

In this report—that is the famous *Narratio Prima*—[32] which later used to be printed in nearly all the editions of the *De Revolutionibus,* we find besides an exposition of the Copernican Astronomy and some very precious biographical data, a very curious astrological explanation of the historical importance of the variation of the excentricity of the orb of the Earth.[33]

The *Narratio Prima* insists on the fact, even more strongly than Copernicus, that the new astronomy is true to the principle of the

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[31] "I have mastered the first three books, grasped the general idea of the fourth and begun to conceive the hypotheses of the rest," writes Rheticus to Schöner; cf. *Narratio Prima,* p. 110 (Ed. Rosen).

[32] The *Narratio Prima* is now available in an excellent translation of E. Rosen, published in his *Three Copernican treatises,* New York, 1939; as for the *Commentariolus,* I am quoting Rosen's translation.

[33] In the Copernican system the orb of the Earth has its center on a small excentric circle, whose center is in the sun.

uniform circular motion of the celestial bodies. Thus, explaining the theory of the lunar motions Joachim Rheticus states (p. 135): "here, in the case of the Moon we are liberated from an equant by the assumption of this theory which, moreover, corresponds to experience and all the observations." To this Rheticus adds: "my teacher dispenses with equants for the other planets as well," wherefore (p. 136): "only on the basis of this theory could all the circles in the universe be satisfactorily made to revolve uniformly and regularly about their own centers and not about other centers—an essential property of circular motion."

For Rheticus the new astronomy is the revival of an old philosophical lore. According to him, it is "following Plato and the Pythagoreans, the greatest mathematicians of that divine age, that my teacher thought that in order to determine the cause of the phenomena, circular motions must be ascribed to the spherical Earth." (p. 147). Besides, "the ancients, not to mention the Pythagoreans, were sufficiently clear about the fact (that) the planets evidently have the centers of their deferents in the sun, as the center of the Universe."

The *Narratio Prima* is rather helpful toward an understanding of the teaching of Nicolaus Copernicus, and I shall have to quote it frequently. But now let us come back to its historical astrology.

Rheticus—but, personally I have no doubt that it was Copernicus speaking through his pen—[34] states that, when the excentricity was at its maximum, "the Roman government became a monarchy; as the excentricity reached its boundary and quadrant of mean value, the Mohammedan faith was established; another great empire came into being and grew very rapidly with the change in the excentricity. A hundred years hence, when the excentricity will be at its minimum, this empire will have completed its period. In our time it is at its pinnacle from which equally swiftly, God willing, it will fall with a mighty crash. We look forward to the coming of our Lord Jesus Christ when the center of the excentric reaches the outer boundary of mean value, for it was in that position at the creation of the world. This calculation does not differ very much from the saying of Elijah, who, under divine inspiration prophesied that the world

[34] Dr. E. Rosen points out that, in contradistinction with Rheticus, Copernicus nowhere in his books, asserts a belief in astrology. Dr. Rosen is perfectly right. And yet it seems—to me, at least—difficult to admit that Rheticus, who wrote his *Narratio* with the knowledge and probably under the supervision of Copernicus, would have dared to express these views if they were opposed to those of his master.

would endure only 6000 years, during which time nearly two revolutions are completed. Thus it appears that this small circle is in very truth the Wheel of Fortune, by whose turning the kingdoms of the World have their beginnings and vicissitudes." (p. 122)

This astrological exploitation of the new, heliocentric, astronomy may appear astonishing to us. And even ludicrous. Yet we must not forget that astrology belonged to the best established belief of that time. Kepler himself shared it, not to mention Campanella.

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The *Narratio Prima* met with considerable success. A new edition was published in 1541 *cura et studio* of Achille Ganarus, a Basler physician. The learned world was thus in possession of the first elements of the doctrine.

The first reactions were rather favorable. Thus Erasmus Reinhold, Professor in the University of Wittenberg who, in 1542, issued a reprint of the text book of Peurbach, expresses in its preface the hope to see astronomy restored by Copernicus, whom he calls "a new Ptolemy."

The publication of the *Narratio Prima* made the withholding of the *De Revolutionibus* senseless. We must not be amazed, therefore, to see Copernicus, at last yielding to the urgings of his friends. The priceless manuscript is entrusted to Tiedeman Giese. The latter transmits it to Joachim Rheticus who has it printed by the famous Nuremberg typographer, Johannes Petreius. Tiedeman Giese tells us that Copernicus received the first copy of his work on his deathbead, on May 24, 1543.

All that is fairly well known. We know too, that Joachim Rheticus, appointed professor in the University of Leipzig in 1542, left the supervision of the printing to his friend Andreas Osiander, a famous —and somewhat heretical—Lutheran divine. We know further that Osiander, who had a personal experience of the *rabies theologorum* —and who recognized that there was some danger in the thesis advocated by the new astronomy,— decided to shield it against the ire of the theologians and the Aristotelians, and to take some precautions. As a matter of fact, the boldness of Copernicus troubled Osiander himself. The new world conception was, obviously, contrary to the scriptures and he was himself a good enough—though heretic—Lutheran, to doubt their literal divine inspiration.

Thus, as early as 1541[35], he devised a rather elegant solution of the difficulty by accepting a phenomenist theory of science.

Science, — and especially astronomy, — thinks Osiander has only one purpose, which is to "save the phenomena," *salvare apparentias.* The goal and aim of the astronomer is not to find out the hidden causes nor the real movements of the heavenly bodies,—which he is unable to do—but to connect his observations by means of hypotheses enabling him to calculate the (visible and apparent) positions of the stars and the planets. These hypotheses, that of Copernicus no more than those of others, make (or need not to make), therefore, any pretension (or claim) for being true or even verisimilar or probable; they are nothing more than calculatory devices, and the best of them is not the truest but the simplest and the most convenient.

This is what Osiander explains in a letter-preface "To the reader of this work," which he prefixes without his signature to the text of the *De Revolutionibus,* thus making the reader believe that its author was Copernicus himself.

This very interesting and very modern looking piece of epistemology, very curious and very valuable from the point of view of the history of philosophy and science,[36] nevertheless had the misfortune to be very severely judged by the friends of Copernicus.

Tiedeman Giese ascribes it to the envy and the cowardice of a man who himself refuses to abandon his traditional views and beliefs and prefers to commit a real forgery, aggravating it by a breach of confidence.

Tiedeman Giese wants Osiander to make a public declaration of authorship. He asks the magistrate of Nuremberg to order the suppression of the foreword. He even asks for the reimpression of the first pages of the *De Revolutionibus* with an announcement that the foreword is a forgery. Giese thinks that Joachim Rheticus

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[35] April 20, 1541 he wrote, on the same day, to Rheticus and to Copernicus himself, exhorting them to adopt the phenomenistic epistemology and, in order to placate the theologians and the Aristotelians, to present the new world system as a purely mathematical "hypothesis." Copernicus answered with a refusal. The whole story is told by Kepler in his—unfortunately unfinished and inedited—*Apologia Tychonis contra Ursum,* printed for the first time by Frisch in his edition of Kepler's *Opera omnia.*

[36] As I have mentioned already, the epistemology of Osiander is by no means new and modern, but on the contrary, very old and trivial. Cf. Pierre Duhem, *La théorie physique,* Paris, 1906.

should take the matter in hand. It is to him that he sends his complaint to the magistrate.

It is probable that Joachim Rheticus saw things in a different light from Leipzig than Tiedeman Giese saw them from Kulm. He seems to have done nothing. Not only did he not assail Osiander, nor did he contradict him,—but he even suffered the foreword to be reprinted in the second, Basle 1566, edition of the *De Revolutionibus,* an edition to which his own *Narratio prima* was added as introduction, without any mention of Osiander.

We must confess that, though they believed the foreword to emanate from Copernicus himself, this declaration of phenomenist faith did not deceive the initiated. They thought, simply, that Copernicus took precautions.[37]

As a matter of fact, Copernicus took very few, if any, precautions.[38] He joined to his book the letter he had received from the Cardinal of Capoua some years before. He dedicated his work to Pope Paul III. But in his own, very noble forewarding letter (which Osiander did not publish), he insists proudly and unflinchingly upon the rights of science and philosophy. *Mathemata Mathematicis scribuntur,* he proclaims; the ignorant should better keep silent. And the allusion to Lactantius who made himself ludicrous by not wanting to believe in the rotundity of the Earth, is a rather broad hint: it is not enough to be a good Chrisian, or even a good theologian in order to be qualified to discuss things astronomical. In this forewarding letter Copernicus explains why he attempted the elaboration of a new theory of planetary movements. It was the disagreement among the mathematicians, the variance that prevailed among them, the multiplicity of the astronomical systems (Copernicus quotes the systems of homocentric spheres, of epycicles, of excentrics), as well as the failures of all of them to represent exactly the apparent movements, or to remain faithful to the principle of the *uniform* circular motion of the heavenly bodies, that made him think that the "mathematicians" had either neglected some essential principle, or, on the contrary, had introduced some false assumption into their constructions. This would explain their failure. But what was their error?

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[37] Thus Petrus Ramus reproached Copernicus for his lack of courage, wherefore Kepler vigorously defended him. Cf. Kepler, *Astronomia Nova,* ed. Frisch vol. III, p. 136. Gassendi mentions the facts in his *Vita Copernici,* Paris, 1654, p. 391.

[38] In the body of his work he deals with the physical objections formulated by Ptolomy against the motion of the Earth: cf. *infra.*

Copernicus informs us that in order to discover that error he had read all the books of the philosophers dealing with this question. He discovered that some of them believed in the movement of the Earth. This gave him heart to try out this hypothesis himself, and to see if it did not furnish a better explanation of the celestial phenomena. As a matter of fact, he found that such was precisely the case, and that, moreover, one obtained in this way a perfectly well ordered Universe.[39]

It had been the error of the mathematicians to have made the Earth the center of the world and of the celestial movements.

M. Dreyer, the author of one of the best modern histories of astronomy, remarks in this connection (p. 312): According to this statement Copernicus first noticed how great was the difference of opinion among learned men as to the planetary motions, next he noticed that some had even attributed some motion to the Earth and finally he considered whether any assumption of that kind would help matters. We might have guessed as much even if he had not told us.

M. Dreyer who, obviously, has slight confidence in the sincerity and outspokenness of Copernicus' writing to the Pope, thinks that the information given to us by the former does not enable us to give an answer to the question: What urged Copernicus to place the sun in the center of the word? Was he influenced by his reading of the ancient philosophers? Does he owe the first idea of his system to Aristarchus of Samos? Or else did he work out the heliocentric astronomy first and then find in the writings of the ancients encouragement and corroboration?[40]

It is true that the account of Copernicus is somewhat reserved and reticent. And yet, if he does not give us the history of his thought, he gives us, nevertheless, some precious, though scanty, indications about its incentives and its motives.

Copernicus, as a matter of fact, tells us, and very clearly so, his objections to all the other systems of ancient and medieval astronomy: it is, in the first place, the fact that they are unable to remain

[39] N. Copernicus, *De Revolutionibus*. Preface: "The order and the magnitude of the stars and their orbs and the heaven itself are so connected that in no part can anything be transposed without confusion to the rest and to the whole Universe."

[40] Aristarchos of Samos is not mentioned in the printed work. Yet, in the MS his name follows those of Philolaos and Hiketas.

faithful to the principle of the *uniformity* of the circular motion of the heavenly bodies, which in Copernicus' opinion means that they are *physically impossible.* It is, in the second place, the fact that they give us a disconnected and irrational picture of the Universe.

* * *

In the body of his book, Copernicus, in setting forth the difficulties inherent in the theory of the movements of Venus and Mercury, gives an account of a theory, mentioned by Martianus Capella, according to which both planets center their movements around the Sun, or, more simply, revolve around the Sun. He adds that if anybody were to follow this hint, he would make the Sun the center of the movements of Saturn, Jupiter and Mars, and would have found the true explanation of their movements. Is this perhaps a reminiscence of the path his thought had followed?

In the *Narratio prima* J. Rheticus says that it was the great variations in the brightness of the planet Mars . . . which no geocentric theory could explain that convinced Copernicus that this planet did not revolve around the Earth, but had the center of its movements in the Sun. This seems to point to the same trend of thought. And yet, if Copernicus had reasoned according to this pattern, he would have developed the system of Tycho Brahe.[41] Not his own.

It may be, as Apelt and Dreyer point out, that Copernicus noticed that the movement of the sun along the zodiac played a very important part in the astronomy of Ptolemy; particularly, that the period of revolution of the deferent of the inner, was equal to one year and that of the epicycles of the outer to the synodic period.[42] Joachim Rheticus seems to confirm this assumption. He says in his *Commentariolus* (p. 139) that "Under the commonly accepted principles of astronomy, it could be seen that all the celestial phenomena conform to the mean motion of the sun and that the entire harmony of the celestial motions is established and preserved under its con-

[41] In Tycho Brahe's astronomy the planets revolve around the sun, and the whole system revolves around the immobile Earth. From the point of view of calculations—which deal only with relative positions and motions—there is absolutely no difference between this system and that of Copernicus. The reason why Tycho Brahe imagined this device seems to be the fact that the Copernicans were unable to refute the *physical* objections against the motion of the Earth.

[42] Cf. Dreyer, op. cit., p. 312: "It must have struck him as a strange coincidence that the revolution of the sun round the zodiac and the revolution of the epicycles' centers of Mercury and Venus round the zodiac should take the same period, a year, while the period of the three outer planets in their epicycles was the synodic period, i.e. the time between two successive oppositions to the sun."

trol. Hence the sun was called by the ancients leader, governor of nature, and king." (p. 139). It was not very difficult to deduce from this statement that the above mentioned circles were nothing else than the projection of the orbital motion of the Earth around the Sun; and, perhaps, to back this discovery by the contention that, in order to exercise his power and leadership the Sun had no need to travel around the world; just as "the Emperor does not hurry from place to place to impose his rule and authority on his realm" (*id.*); and finally, to affirm that, after having created the Sun

> To whose rhythm the gods move, and the world
> Receives its laws and keeps its pace ordained

"God stationed in the center of the stage this governor of nature, king of the entire Universe, conspicuous by its divine splendor" (p. 142).

All that is possible. Copernicus, as well as Rheticus, is full of Pythagorism.

Copernicus objects to the Astronomy of his time because of its great complication. It is better to admit the movement of the Earth, says he, though it may appear absurd, than to let one's mind be distorted and torn asunder by the nearly infinite multitude of circles and orbs of the geocentric astronomy. And, as a matter of fact, when we see the schematic picture of his system of the Universe, we are taken in by its apparent simplicity and beauty. Yet, this impression is not quite correct. The number of circles in the astronomy of Ptolemy was not as large as he says. And they were by no means absent in that of Copernicus. There were 42 cycles in the system of Ptolemy. And there are 34 in the Copernican. Eight cycles is all we gain. Those who thought that the gain was not big enough for the price cannot be blamed.

Strange as it seems, Copernicus does not particularly insist in the *De Revolutionibus* on the real gain of his system: on its *physical* systematization and simplification, on the fact that a great number of particular movements of the celestial bodies are, from now on, explained as the apparent result of one and only one real movement, namely the movement of the Earth. Nor does he insist on the fact that the role of the Sun or of the *solar* period in all of the planetary motions is from now on explained in a perfectly easy and natural way.

Yet if Copernicus fails to do so, his pupil does it for him. Rheticus does not only reproach the Ptolemaic system for its endless invention of spheres but opposes to it: "the remarkable symmetry and interconnection of the motions and spheres, as maintained by the assumption of the foregoing hypotheses, are not unworthy of God's workmanship and not unsuited to these divine bodies" (p. 145). Rheticus does not stop with that. He sees a deep meaning and a confirmation of the Copernican astronomy not only (as Copernicus himself) in the fact that the speed — or the slowness — of the planetary movements correspond to their distance from the Sun, but even in the fact that this astronomy reduces their number from seven to six: There are, in the Copernican world, no more than "six moving spheres which revolve about the sun, the center of the universe." And Rheticus adds (p. 146, 7), "Who could have chosen a more suitable and more appropriate number than six? By what number could anyone more easily have persuaded mankind that the whole Universe was divided into spheres by God the Author and Creator of the World? For the number six is beyond all others in the sacred prophesies of God and by the Pythagoreans and other philosophers. What is more agreeable to God's handiwork than that his first and most perfect work should be summed up in the first and most perfect number?"

Another objection of Copernicus to the Ptolemaic astronomy —a philosophical one—appears at first glance to be very strong. Copernicus says—and, of course, he is quite right—that it is absurd to want to move the *locus* and not the *locatum,* and that, therefore, the starry sky which, according to Aristotle, is the *locus* of the Universe, must be considered as unmoved.

This seems to us a perfectly well reasoned out argument. Indeed, we feel that it is contrary to reason (and even, perhaps, to common sense) to let the whole immense (or, for us, infinite) Universe revolve around a tiny speck of dust. We feel convinced. But the Aristotelian (or Ptolemaic) is not. His Universe, though pretty large,[43]

[43] The Universe of Copernicus is *immensum,* that is immeasurable; yet not infinite. It is much larger than the Universe of Ptolemy (though this, too, was rather large) because Copernicus must explain why—if the Earth *does* move on its orbit around the sun—the (fixed) stars appear always in the same position; in other terms, why there is no paralax? Copernicus answers by assuming that the dimensions of the sphere of the fixed stars is "in no proportion" with that of the orb of the Earth, and therefore, literally, immeasurable. No wonder that this answer did not appeal to his contemporaries. We must not blame them: we must admire the boldness of Copernicus.

is by no means immense (and he objects to its—from his point of view—motiveless extension by Copernicus[44]); he feels that there is a fundamental, qualitative, opposition between the heavy, inert Earth and the imponderable heavenly spheres: to move the first an external, material motor of a tremendous power would be needed; the motion of the latter, on the contrary, is a sequel of their perfection, of their nature itself. Therefore, concludes the Ptolemaic from the self same premises as Copernicus, the mobile sphere is *not* the *locus* of the Universe, and thus, we must admit above it another one, which is the true, immobile sphere (the eighth, or ninth, or tenth . . .)

The proofs that Copernicus advances for his system are curious. In fact, they do not *prove* anything at all. From the point of view of his adversaries they are worthless. His refutation of the physical objections of the Ptolemaics against the motion of the Earth are, too, rather feeble. Withal, they are of a tremendous historical importance.

Copernicus shows us that, from the optical point of view, it is impossible to decide whether it is the observer or the observed who are in motion. Quite right, would the Ptolemaic answer; the well known relativity of motion[45] implies doubtlessly that the motion of the Earth is optically *possible*. But it implies at the same time—always from the optical point of view—that it does not present any advantage as compared with its immobility.

To the physical objection that the rotation of the Earth would engender a tremendous centrifugal power which would blow it to pieces, Copernicus replies that the self same objection could be raised against the motion of the skies, the more so as the velocity of their motion is infinitely greater than that of the Earth.

As a matter of fact, from the point of view of the Ptolemaic, Copernicus is wrong, because the motion of the heavenly spheres, considered as imponderables, is of a quite different nature from that of the ponderable Earth, and could not give birth to a centrifugal force. Besides, the revolution of the skies being for them a natural

[44] Once more we must not blame Copernicus for that, but on the contrary, admire him more because, as a matter of fact, no *proof* was possible without an extensive use of optical instruments and without an elaboration of a new physics, i.e. not before the middle, or even the end, of the XVIIth century.

[45] On the theories of space and motion cf. P. Duhem, *Le mouvement absolu et le mouvement relatif,* Paris, 1905.

motion, cannot be the cause of an effect which would endanger their conservation and being.

We must not smile at these arguments.[46] From the point of view of the Aristotelian physics they are perfectly valid. Besides, Copernicus himself makes use of them in order to show that, if the Earth revolved around its axis, it would be a *natural* motion, wherefore none of the effects deduced (hypothetically) by Ptolemy, *on the assumption that this motion would be a violent one* and *contra naturam,* would, as a matter of fact, take place.

We see that Copernicus—as everybody until Galileo and Descartes—accepts the distinction between *natural* and *violent* motions; he only asserts that the same laws apply to the Heavens and to the Earth and, by doing this, he lays the ground for that deep-reaching transformation of human thought to which History has given the name of *Copernican Revolution.*

But this we shall see more clearly by glancing at the Copernican dynamics.

* * *

The dynamics of Copernicus is by no means "modern." Nevertheless, an abyss separates it from that of his contemporaries, because, spontaneously and unhesitatingly he applies the geometrical point of view to the Universe. Even his esthetics is a geometrical one: the esthetics of geometry, or more exactly, of geometrical optics. His physics, too—though he never says so *expressis verbis,* and perhaps does not even recognize it clearly and distinctly—is a geometrical physics.

Not quite, of course. Copernicus still uses a "physics," that is a theory of nature, or better to say, a theory of natures; and yet the geometrization of his thought is deep and strong enough to transform completely the fundamental Aristotelian notion of *form* itself. Thus, when and where medieval and classical physics talked about *form,* they usually meant: substantial forms; Copernicus, on the contrary, has *geometrical form* in mind.

The implications, as may be seen readily, are numerous and far-reaching. For instance, whereas for ancient physics it was the specific

[46] For the discussion of these arguments cf. my *N. Copernic, Des Révolutions des Orbes célestes,* 1.I., texte, traduction, notes, Paris, 1933 et my *Etudes Galiléennes,* v. III, Paris, 1940.

nature of a definite substantial form (and, of course, of the corresponding matter) which determined the kind of *natural* movement pertaining to a body (rectilinear for the sublunar, circular for the heavenly bodies), it is its geometrical form which plays that rôle for Copernicus. If the celestial bodies move around themselves, it is not because they have a specific nature, it is simply because they are spherical.

Copernicus seems to believe that the spherical shape,—the geometrically most perfect form that all natural bodies seek for this reason — naturally engenders the most perfect, the most *natural* movement, i.e. the circular one. Thus (a) the same reasoning enables and even obliges us to ascribe to the Earth the same circular motion with which the planets are endowed (and this is the reason why Copernicus dwells at such length and with such a profusion of arguments upon the sphericity of the Earth which nobody in his time doubted, and which—if it were not so tremendously important —could therefore be treated as a matter of common knowledge) (b) the same laws of motion which apply to the planets, are valid also for the Earth, (c) partaking of the same circular form, and following the same laws of motion, the Earth no longer stands in opposition to the moving heavenly bodies as a world apart—an Underworld—but forms *with them* a single and unique Universe.

The geometrization of the concept of form placed the Earth among the stars, and, so to say, lifted it into the skies.

We understand now why Copernicus attributes such an importance to the rule or principle of the *uniform circular motion* and considers it as the basis of his whole celestial mechanics.

It was, for him, the only means to put the *machina mundi* into motion. In the dynamics of Copernicus—a curious dynamics, as we are seeing, a dynamics which he had, perhaps, inherited from Nicolaus of Cues,[47] the (circular) movement is caused by (or due to) the (spherical) form of the bodies. The bodies turn around because they are round, without an external (or even internal) motor. Put a round body (a sphere) into space, and it will turn around. Place an orb into it: it, too, will revolve around itself, without having any need either of a motor to keep up its movement, or of a *physical center* which would support it. And this is the dynamical reason

[47] Cf. Riccioli, *Almagestum Novum*, Bononiae, 1651, and L. Birkenmajer, *Mikołaj Kopernik*, Kraków, 1900, p. 461.

why, having expelled the Earth from the center of the movements of the World, Copernicus can leave it empty.

It is a fact that, if Copernicus places the Sun in the center of the Universe, he *does not* place it in the center of the celestial movements. The sun does not play any role in the celestial mechanics of Copernicus. Its role is quite different. It is purely optical. It lights, or gives light, to the Universe—and that is all.

Yet I am quite wrong in saying: that is all. For the function performed by the sun, the function of illuminating and lighting the Universe, is, for Copernicus, of extreme and supreme importance. It is this function which explains and secures the place that it holds in the World: first in dignity and central in position. It is in order to give light to the Universe that the sun, this *lampada pulcherrima,* is placed in its center—a position that is, obviously, the most fitting for this end. And this is the reason—the true reason—which inspired the thought and the soul of Copernicus. It is not a purely scientific reason. It is much more than that.

Old traditions, the tradition of the metaphysics of light (metaphysics which during the entire Middle Ages bears and accompanies the study of the geometrical optics), Platonic and New Platonic or Pythagorean reminiscences and revivals (the visible sun representing the invisible one, the sun being the master and king of the visible world and thus representing God) can alone—at least in my opinion,—explain the emotion with which Copernicus speaks about the Sun. He adores it, and almost deifies it.[48]

People who, like Digby and Bruno, and others, have linked the Copernican astronomy with a kind of heliolatry, who, at the same time have felt themselves raised into the skies, were by no means infidel to the inspiration of the great Polish thinker.

Copernicus, as I have said it so often and as Dreyer has said it long before me, is not a Copernican. He is not a "modern." His Universe is not the infinite space of the classical physics. It has limits, just as that of Aristotle. It is larger, of course, much larger,

[48] N. Copernicus, *De Revolutionibus,* cap. X "For who could in this most beautiful temple place this lamp in another or better place than that from which it can at the same time illuminate the whole? Which some not unsuitably call the light of the world, others the soul of the ruler. Trismegistus calls it the visible God, the Electra of Sophocles the All seeing. So indeed the Sun, sitting on the royal throne, steers the revolving family of stars."

so large as to be *immeasurable* (*immensum*), and yet finite, contained in, and limited by, the sphere of the fixed stars. The sun is in its center. And, around the sun rise the orbs (which bear and carry the planets), orbs just as real as the crystalline spheres of the medieval cosmology.[49] The orbs revolve because of their form and carry with them the wandering planets, which are set in them as jewels are set in their mount. . . .

Splendid order, luminous astro-geometry, magnificent cosmo-optics, which replaces the astro-biology of the Ancients.

* * *

The ways of Spirit, as the ways of God, are quaint and curious. And truly great minds are only inflamed and inspired by infinite goals.

[49] As I have already stated (cf. *Supra* p. 713, n. 21; p. 720) not all astronomers believed in the physical reality of their spheres, orbs, and circles. Tycho Brahe, for instance, did not. Copernicus, on the other hand, certainly did. This may appear strange to us, and we may feel inclined to ask: how could he believe in the orb of the Earth? Yet Kepler confirms my interpretation (Cf. Kepler, *Opera Omnia,* VII, p. 181). Once more, we must not modernize the thought of Copernicus. Besides, we must not forget that even Descartes found no difficulty whatever in this conception and felt himself compelled, in order to explain the movements of the Earth and of the planets, to admit, for dynamic reasons, the existence of some kind of orbs (which he called *tourbillons*).

THE WORK OF COPERNICUS AND THE STRUCTURE OF THE UNIVERSE*

By PROFESSOR OTTO STRUVE
University of Chicago

We are gathered here today to honor the memory of a man who stood between the ages of superstition and of science, between blind faith in authority and cold logic of reasoning, between astrology and astronomy. His own contemporaries spoke of his ideas as "the new astronomy" to distinguish them from the old astronomy which had been current since the days of Ptolemy. The publication in 1543 of the great work of Copernicus *"De Revolutionibus Orbium Coelestium"* marks the beginning of an intellectual revolution which lasted for more than one hundred years and culminated in the three laws of planetary motions enunciated by Kepler and the law of universal gravitation proposed by Newton in 1687. Copernicus started the revolution because he recognized that the sun, and not the earth, stands in the center of the solar system. Kepler strengthened the foundations of the new astronomy because he recognized that the paths of the earth and of the rest of the planets need not be circular, but are usually elongated curves which the mathematicians call ellipses; and Newton gave final victory to the revolution because he found the universal force which keeps the planets in their orbits and draws them constantly toward the sun.

To us, in the twentieth century, the Copernican revolution is of special interest and significance because we ourselves have witnessed the closing phases of another intellectual and scientific revolution, which started about 100 years ago when astronomers first began to doubt that the solar system is located near the center of our Milky Way galactic system. The new galactic revolution has lasted a

*The reader is referred to the following literature from which some of the quotations in this article have been taken:

1) "The Gradual Acceptance of the Copernican Theory of the Universe," by Dorothy Stimson, New York, 1917.

2) "Copernicus, The Founder of Modern Astronomy," by Angus Armitage, London, 1938.

3) "History of the Planetary Systems," by J. L. E. Dreyer, Cambridge, 1906.

century, and, like the Copernican revolution 400 years before, has resulted in the recognition that the sun is but a small star among a billion other stars which make up the Milky Way, and that the solar system is located a long way from the center of this stupendous agglomeration of stars and nebulae.

The two revolutions have many aspects in common. Both had to struggle against faith in "common sense". The erroneous system of Ptolemy was founded upon the idea that our senses give us no direct sensation of motion. Hence Ptolemy argued that those people who thought the earth could turn around its axis "do not realize how very ridiculous their opinion is in view of what takes place around us and in the air." He believed that the atmosphere and the clouds which float in it cannot be attached to the earth and consequently should be left behind if the earth turned around its axis. Since no such effect was observed, he felt certain that the earth does not rotate, and that the daily cycle of day and night, of sunrise and sunset, must be caused by the revolution around the earth of a large crystal sphere to which the sun is firmly attached. Common sense seemed to justify this conclusion. Indeed, Ptolemy had no reason to doubt that the air extended throughout cosmic space, like the gaseous substratum of the galaxy recognized by modern research, and it was completely logical to follow the dictum of common sense: the air is apparently stationary with respect to the earth. Hence, the earth must be stationary. Otherwise the clouds would float toward the west, as do the stars and the sun. If the earth is stationary in space, then the daily rising and setting of all celestial objects must be caused by the rotation around the earth of a large sphere, the "primum mobile," whose motion is transmitted by some such action as friction to the eight inner spheres which carry the Moon, the Sun, the five planets (Mercury, Venus, Mars, Jupiter, and Saturn) and the fixed stars. Uranus, Neptune, and Pluto had not yet been discovered.

In the new revolution there was an equally compelling common-sense reason to think that the solar system is in the center of the galaxy. On a clear, moonless night the Milky Way appears like a huge ring around us, and our first impression is that we are located near the center of this ring, in something like a preferential position with respect to the other stars. Moreover, Sir William Herschel had counted, about 150 years ago, all stars of different brightnesses, in definite areas of the sky. These counts showed conclusively that the

numbers of faint stars fail to increase as rapidly with decreasing brightness as we should have expected if they were uniformly distributed through space. The common-sense conclusion was that the stars thin out at great distances. This thinning out is the same in different directions. Hence, the solar system must be in the center of the galaxy.

It is a remarkable coincidence that in both revolutions the common-sense arguments turned out to be wrong. In both they were well founded and carried a great deal of weight. But in both revolutions the overwhelming evidence in favor of the new conceptions of the universe compelled their originators to abandon common-sense and thereby to open the way to new discoveries. Copernicus, after some thirty years of study, established the fact that contrary to Ptolemy's common-sense arguments against rotation and revolution, the observed motions of the planets are such as to practically compel an interpretation in terms of an annual revolution of the earth around the sun and a daily rotation of the earth around its axis. Being faced with a contradiction between the results of his new theory and the evidence of common sense, Copernicus carefully weighed the two sides and concluded that although his theory was so "contrary to the accepted opinion of mathematicians and in like manner contrary to common sense" that he "hesitated long" whether he should "give to the light" his commentaries composed in proof of this motion, he nevertheless, had to accept the hypothesis of the Earth's motion as a statement of physical fact, and consequently had to suppose that the atmosphere with the clouds in it is carried with the earth around the latter's axis. The crucial observations which led Copernicus to this far-reaching conclusion were first, the retrograde motion among the stars (from east to west) of the superior planets Mars, Jupiter, and Saturn, during their oppositions, and second, the close proximity to the sun as seen in the sky, at all times, of the inferior planets Mercury and Venus. These two phenomena were explained in a very awkward manner by Ptolemy: he supposed that the planets revolve around a small circular path, the epicycle, the center of which in turn revolves in a circular (but eccentric) path—the deferent—around the earth. At opposition, the motion in the deferent is, as always, from west to east; but the faster motion in the epicycle is from east to west so that, as seen from the earth, the planet retrogrades. The motions of Mercury and Venus were explained by Ptolemy by supposing that the deferents of both

planets had the same period as the sun, so that they would only oscillate back and forth from west to east and from east to west of the sun, as they revolve in their respective epicycles.

These two unrelated theories for the two groups of planets were possible; but Copernicus recognized their artificiality and at once resolved the difficulty by assuming that the earth revolves around the sun, as do the other planets. Then the inferior planets will automatically remain forever in the vicinity of the sun, as seen in the sky; because of the greater speed of the earth in its orbit, it will overtake the superior planets once each year at the latters' opposition, giving them an apparent retrograde motion. No one can deny that this ingenious idea was so plausible that it rendered valueless all objections based upon common sense. But it is one thing to propose a brilliant idea and another to prove it. Evidently, the idea had come to Copernicus early in his life. But he felt that it was necessary to reconstruct the entire mathematical theory of the planetary system and to show that the observations were actually numerically in accord with the hypothesis that the earth has three motions: the daily rotation, the annual revolution, and the annual trepidation. The latter motion does not actually exist. In the words of Kepler "the said motion is, in truth, not motion at all, but rather rest." The bulk of *De Revolutionibus* contains a detailed mathematical study of the motions within the solar system, in which Copernicus retained the description in terms of deferents and epicycles. He showed that this description was far simpler than that based upon the geocentric theory of Ptolemy.

In the new revolution, the crucial problem was that of the transparency of space. If interstellar space were perfectly transparent, so that the light of the stars should diminish inversely as the square of their distances, then the solar system would have to be at the center of the galaxy. But if interstellar space is filled with clouds of absorbing gas and dust, then the strange diminution in star numbers observed by Herschel might not be due to a decrease in the star density away from the sun, but might be caused by absorption.

From the modern point of view, the most serious objection to the theory of Copernicus was the absence of any perceptible apparent displacement of the positions of the fixed stars as the earth pursues its annual path around the sun. Copernicus concluded that the stars must be so far away that their parallaxes would be negligible. But

the greatest observational astronomer of the sixteenth century, Tycho Brahe, could not reconcile this absence of measurable parallaxes with the proposed motion of the earth, and therefore remained, to his death, opposed to the new astronomy. Similarly, in the new galactic revolution, some of the greatest astronomers of the past generation, for example Hugo von Seeliger of Munich refused to accept a theory which did not place the sun near the center of the galaxy, because during his life time no one had brought any conclusive and unambiguous proof that there existed a measurable amount of absorption in space.

The discovery of stellar parallaxes (in 1837) came long after Tycho Brahe's death and much too late to be of any assistance in the acceptance of the Copernican system. The work of Galileo and of others had long before created so firm a basis for the new astronomy that there was no need to wait for the first successful measurement of a stellar distance. Astronomers knew that the Copernican system must be right, and predicted that the parallaxes would be smaller than any that Tycho Brahe could have measured with his instruments. This prediction was fully confirmed in 1837.

In the galactic revolution the final proof of the existence of absorbing matter came gradually through the accumulation of accurate observations. First, E. E. Barnard of the Yerkes Observatory and Max Wolf of Heidelberg developed the technique of astronomical photography and showed that what Herschel had regarded as "veritable holes in the heavens" are really clouds of finely divided dust in interstellar space. Other astronomers, notably H. N. Russell of Princeton, soon afterwards concluded that distant stars seen through such dust clouds are reddened—as the sun is reddened by the atmosphere near the horizon. But the final acceptance of the theory of absorption and of its corrollary, the hypothesis of an eccentric position of the sun in the galaxy, came suddenly in 1930, when R. Trumpler of the Lick Observatory published the results of his observations on open star clusters in the galaxy. The clusters are groups of stars numbering a hundred or more. These structures are known to be closely similar to one another in size and composition. The apparent angular diameters of the clusters as observed by Trumpler should be proportional to their relative distances from the earth. But Trumpler found that the smaller, and hence more distant, clusters consisted of fainter stars than those he had expected to find. For example, if one cluster had a diameter one-half that of

another cluster, he reasoned that their distances were in the ratio of two to one. Since light-intensity diminishes inversely as the square of the distance, he expected the stars of the smaller cluster to be four times fainter than those of the larger cluster. In reality they were about six times fainter. The excess of faintness he attributed to general absorption of light in space.

The tremendous effect produced upon astronomy by this remarkable paper will be remembered by many astronomers as one of the most astonishing experiences of their careers. True, there had been other indications of the impending victory of the new revolution. But earlier publications, some of which were almost as convincing as the work of Trumpler, were left without much attention. I recall a paper by the Swedish astrophysicist Schalén, which brought together much valuable evidence in favor of absorption; but it merited only a casual remark by a competent reviewer to the effect that such discussions of interstellar absorption had only minor interest: the whole world knew that there was no such thing as interstellar absorption!

Both revolutions won their victories through the improvement of observational techniques. The work of Copernicus would have remained sterile had not Tycho Brahe produced a series of observations of Mars of unsurpassed precision. Kepler discussed these observations and derived from them his first two laws of planetary motion. Even then the new astronomy would probably have remained without success had it not been for the discovery of the telescope by Galileo in 1610 and for his observations of the four bright satellites of Jupiter which showed at a glance to anyone who wanted to see it, a miniature planetary system in action. Similarly his discovery of sun-spots dispelled some of the old ideas of Ptolemy.

In the galactic revolution the principal observational improvement consisted in the invention of the photographic process. Without it we should doubtless today believe that the galaxy is a relatively small lens-shaped aggregation of stars, with the sun near its center.

Both revolutions opened the way for a remarkable development of astronomical thought. The work of Copernicus paved the way for Kepler and Newton and resulted in the development of what is now designated as dynamical astronomy. The recognition of the true

dimensions of the galaxy and of the eccentric position of the sun in it gave added importance to the investigations by Shapley of the system of globular clusters, by Hubble of the extraneous galaxies and by Oort of the phenomenon of galacitic rotation.

But in one important respect the Copernican revolution differs very markedly from the new galactic revolution, and this difference is especially important in appraising the stature of Copernicus as a scientist. The entire introduction to *De Revolutionibus,* addressed to "His Holiness, Paul III, Supreme Pontiff" gives evidence of the overwhelming belief in "authority" which dominated all medieval science. Great scientists before him, like Hipparchus and Ptolemy had unequivocally pronounced against the earth's having any motions, and the church with all its power had accepted these pronouncements as the truth. No wonder then that he had hesitated "not for nine years alone, but also into the fourth novenium" to make public a theory in which he "had dared to imagine any motion of the earth, contrary to the accepted opinion of mathematicians and in like manner contrary to common sense." It required an extraordinary independence and great moral fortitude to ignore the positive statements of recognized authorities at a time when scientific thinking was little appreciated. Copernicus was a product of the age in which he lived. But he had the mental power to lift himself above the conventions of medieval science and to trust only his own mathematical reasoning. He did this at the risk of ridicule and persecution. Although the Catholic Church, of which he was a canon, not only did not molest him, but even provided him with the leisure and the material means which made his work possible, Luther and Melanchthon denounced him as "a fool who sought to over-turn the whole science of astronomy." The fate of Giordano Bruno who was burned at the stake in 1600 for proclaiming revolutionary scientific ideas and the fate of Galileo Galilei, who in 1633 was imprisoned and tried by the Holy Office in Rome for having taught and upheld the Copernican doctrine demonstrate very clearly that the leaders of the Copernican revolution were not only great scientists, but brave men as well.

In the galactic revolution of the past one hundred years this element is missing. Copernicus had created the basis for that freedom of science which we so greatly cherish, and the astronomers of the 19th and early 20th centuries were not confronted with hostile and unscientific forces. The word "authority" cannot be found in the writ-

ings of the modern astronomers, and it would appear laughable if anyone should attempt to prove or disprove the theory of interstellar absorption by preparing lists of names of astronomers who were for or against the theory. As late as in 1651 Father Riccioli used this method, among others, to demonstrate the fallacy of the Copernican doctrine; sixteen names are listed for the doctrine and thirty-eight against! The evil forces of totalitarianism have attempted in recent years to again enslave human thought and undo the work of the great liberators of science. Our meeting here tonight is a protest and a challenge: *Crescat Scientia, Vita Excolatur!*

COPERNICUS, THE MAN AND HIS TIMES

By Professor Edmund Zawacki
University of Wisconsin

It is not my purpose to expound the intricacies of the Copernican heliocentric system; that is a task which exceeds my qualifications. Nor shall I try to paint the whole background of XVth and XVIth century Europe against which Copernicus lived and worked; the times were troubled and were far too crowded with important events for me to do that. I intend merely to walk like a tourist into XVth and XVIth century Poland and see Copernicus in the land of his birth.

Poland at the time of Copernicus was a most interesting country. It is indeed a pity that most general histories of Europe dismiss the ten centuries of Polish history with a few words of compassion for the poor Poles during the partitions, give the real or alleged causes of Poland's fall in a footnote, and ignore the preceding eight centuries of her rise, greatness, and concrete achievements.

The achievements were many. In 1473 when Copernicus was born, the University of Kraków was already a hundred years old, and it was already the first university north of the Alps to take a friendly interest in Italian humanism. Even before Copernicus was born, the professors at Kraków were reading and expounding the Roman classics as well as Latin translations of Homer, Xenophon, and Plato. I mention this because there is evidence to show that the first stimuli for Copernicus's creative thinking in astronomy were passages from Cicero.

It was the Italian, Philip Buonacorsi, better known in Poland as Kallimach, who fleeing before persecution by Pope Paul II, found shelter and welcome in the court of King Kazimierz Jagiełło, and pioneered the new learning. The arch-humanist, Conrad Celtes himself, came to Kraków in 1489 especially to study astronomy under the celebrated astronomer and his fellow humanist, Wojciech Brudzewski, the teacher of Copernicus when that shy but promising young man from Toruń on the Vistula finally arrived at the University.

A little later, under King Zygmunt the Old, whose reign spanned the first half of the XVIth century, Poland was on the threshold of her Golden Age. Erasmus of Rotterdam—perhaps the most illustrious humanistic scholar of Western Europe—wrote letter after letter to Zygmunt extolling him as the protector of learning. I am not sure to what extent Erasmus's admiration was inspired by the purchase of a large collection of his manuscripts by the royal chancellor, Jan Laski. Erasmus was not one to value them at a low price. The sum paid out of the royal treasury plus the fact that he was allowed to keep his manuscripts for his own use until his death, undoubtedly disposed him favorably toward his tactful patron. Such tact on the part of royal patrons was rare indeed in the age of Caesar Borgia and Henry VIII.

In Poland at this time as elsewhere in Europe most of the exact sciences were still in their infancy. Botany, as a kindred science to medicine, however, had been quite well pursued at Kraków, for in 1472, Jan Stanko was already able to write a treatise on Polish *flora* giving to herbs and flowers most of the Polish names that are used to-day.

But the chief glories of the University of Kraków were the chairs of astronomy and of astrology. There was an endowed chair of astronomy at Kraków as early as 1406, nearly a hundred years before the next such chair in Central Europe. The study of astrology was similarly established about 1450 on funds provided in the will of the astronomer, Marcin Król of Zórawica. I might point out in this connection that for a long time even after Copernicus these two sciences were very closely related. Astrology was a most respectable science, more respectable than astronomy. Astronomy, indeed, was regarded merely as "theoretical astrology," and all the blame for the failure of astrological predictions to turn out was conveniently thrust upon the imperfections of astronomy.

These two endowed chairs at Kraków ensured far greater regularity and frequency of lectures in astronomy and astrology than could be guaranteed anywhere else in Europe, and they led very swiftly to the rise of a distinct school of astronomers. Perhaps the most famous of this school were Marcin Król, the founder of the chair of astrology, Marcin Bylica, and Wojciech Brudzewski, the teacher of Copernicus. It was to these men, as the legend has it, that Faust made his way in order to complete his studies. Thousands

of students from Poland and abroad thronged to the University of Kraków. Over 3000 freshmen were enrolled in the years from 1501-1510, only about half of them from Poland. The English traveler and scholar, Leonard Coxe, later master of the Abbey School in Reading, was only one of these many enthusiasts of the new learning who expressed their praises of Kraków University. In 1518 Coxe wrote a detailed account of his stay entitled, *De Laudibus Celeberrimae Academiae Cracoviensis.*

Perhaps another stimulus to learning in Poland was the rapid increase in Kraków after 1500 of the number of printing presses and book shops. At first only Latin works were published, but Greek and Hebrew soon followed, and the first Polish book appeared in 1515. After Kraków the most important publishing centers for Polish works were Królewiec (Königsberg) and Brześć (Brest-Litovsk). By 1514, the University had begun the construction of a suitable library building to house the books which by then were being sought after not only by the clergy but by laymen from the towns and the landed gentry.

Political progress in Poland at this time was as great as that in learning, for as early as 1413, the dynastic union between Poland and the Grand Duchy of Lithuania had been cemented into an organic union among nations. At the town of Horodło in 1413, all the rights and privileges of the Polish gentry in the Kingdom of Poland were extended to the corresponding classes in Lithuania. The document by which this was done is indeed a noble one. Here are a few words from it:

> "In the name of the Lord, Amen. May this deed be remembered forever. . . . Through love, laws are established, kingdoms are ruled, cities are set in order, and the welfare of the state is brought to its highest; among all the virtues it is the most to be commended, and if anyone shall hold it in contempt, he will deprive himself of everything good. . . . May love unite us, make us equals, us whom religion and identity of laws and privileges have already joined."

To seal this pact at Horodło, 47 of the great families in Poland conferred their coats of arms upon 47 corresponding Catholic families in Lithuania. Twenty-one years later these privileges with all their rights and liberties were extended to the Greek Orthodox families as well, and from then on there was no discrimination religious

or political among Poles, Lithuanians, and Ruthenians in the incipient republican Commonwealth. The complete union as equals among equals and free with the free was not consummated until 1569, 26 years after the death of Copernicus, when at Lublin on the plains of Eastern Poland, the Kingdom of Poland and the Grand Duchy of Lithuania became a single federated Commonwealth with a common parliament and a commonly elected king.

There are more equally interesting attainments in the establishment of free institutions in Poland during this period, like the legal principle "we shall arrest no one unless convicted by law," 250 years before the Habeas Corpus Act, and the statute passed by the Polish parliament at the height of the religious struggles in XVIth century Europe, "we shall not shed blood for differences in faith or in church practices." But we need not go any further into the general political history of the period in Poland.

Since Copernicus was directly involved, however, like his father and grandfather before him, in the armed disputes between Poland and the Teutonic Order of the Knights of the Cross in what is now East Prussia but what was then the Polish province of Warmia, I ought to mention that in his time Poland and the remnants of the Teutonic Order were intermittently at war. Continual punitive expeditions had to be sent to quell the robbery and plundering of these aggressive monks. Indeed, Copernicus himself frequently interrupted his astronomical observations to bring the law of Poland down upon these monastic brigands. His letter of July 22, 1516, to the Polish king indicting the Order with a long series of crimes is still extant. In it the astronomer characterized the Teutonic Knights as *"praedones, latrones et homines scelerati"* (plunderers, brigands, and criminals). We must assume, besides, that Copernicus was not letting his feelings overcome his sense of decorum and his respect for majesty. He had to be tactful. After all, the Grand Master of the Order, Albrecht von Brandenburg-Ansbach, was King Zygmunt Jagiello's own nephew!

After this hurried tour of the intellectual and political background in Poland let us now turn to the astronomer himself. Copernicus was born in Toruń on the Vistula on February 19, 1473, of an extremely rich and patrician burgher family. His father died quite young, and when the future astronomer was ten years old, he was put with his elder brother and sister under the guardianship of his

uncle, Lucas Watzelrode, Bishop of Warmia. The Bishop was a man of great integrity and influence. He was a close friend of the Primate of Poland, and he enjoyed the confidence of the King himself, but he must have been a cheerless man, for he is reputed never to have been seen to smile. Whether this last report is true or not, he was undoubtedly austere, and to this austerity in his relations with the young Copernicus we may perhaps attribute the shy sensitivity of the future astronomer's character.

Copernicus in his childhood probably attended the parish school of St. John's Church in Toruń, where he was instructed in the traditional subjects of the *trivium* and *quadrivium,* i.e. the three "R's" plus grammar, dialectics and rhetoric. But as in all bigger schools conducted by quite accomplished graduates of the University of Kraków, the *quadrivium* also offered instruction in the liberal arts, that is, in addition to singing and arithmetic, such subjects as geometry, geography, and even astronomy were studied. Nothing is known of Copernicus's record here.

After his father's death, his uncle placed him in the cathedral school at Włocławek, a preparatory school for the university, which at the time was under the head-mastership of the gouty but extremely gentle and accomplished Bishop Piotr Moszyński. Since the gout prevented the good bishop from travelling, he made up for it by inviting to Włocławek all the savants and humanists he could reach. It is known that the pioneer of humanism in Poland, Philip Kallimach Buonacorsi, and his favorite pupil, Maciej Drzewicki, as well as the physician and astronomer, Mikołaj Wodka from Kwidzyń (Marienwerder) were frequent guests at Włocławek. Indeed, Wodka remained there as a member of the Chapter.

Such select company could not be without influence on the quality of instruction in the cathedral school. In the upper classes at Włocławek, Copernicus was already reading Cicero, Terence and Virgil. He must have been an intelligent pupil. Judging by his mature features in what is purported to be a later autoportrait, his face must have been delicately chiselled but tending a bit to length, and his eyes must already have had that strikingly sensitive and somewhat timid expression of the portrait which close association with his severe unsmiling uncle perhaps induced.

There is a tradition that the sundial on the south wall of the cathedral at Włocławek was built in 1490 by Copernicus "with

some other learned man." Copernicus would have been seventeen at the time. If there is any truth in the legend, that "other learned man" must certainly have been Mikołaj Wodka, who is known to have been an enthusiast of gnomontic science, and who perhaps was the first to initiate the youthful Copernicus in the mysteries of the stars.

In the autumn of 1491 Copernicus enrolled in the University of Kraków. It may safely be assumed that he made rapid progress in his university courses. What with his natural ability and his excellent preparation at Włocławek he was perhaps at once permitted to attend certain of the lectures in mathematics. By painstaking research and great ingenuity Dr. Ludwik Birkenmajer, one of Poland's outstanding Copernican scholars, and the father of my late predecessor here at Wisconsin, reconstructed the probable course of study which Copernicus completed at Kraków. Euclidian geometry appears to have been a passion with him, but he did not neglect his Latin classics, for evidences of his preoccupation with Latin translations of Plato, particularly with the dialogue *Timaios* are numerous in the notes and jottings left by him. It was perhaps from Plato that he first learned to be sceptical about the testimony of the senses.

Finally, with his mind avid for Platonic idealism but imbued with humanistic admiration of nature, and with his soul piously humble before the harmony and perfection of the universe as it was then conceived, we see the young Copernicus entering upon the serious study of astronomy under the celebrated teacher, astronomer, and humanist, Wojciech Brudzewski. Very shortly the older humanist and the brilliant young pupil became good friends. The association was stimulating to Copernicus. Wojciech Brudzewski, of course, expounded the Ptolemaic geocentric theory of the universe, for that was his job as a professor of the University. He was, however, extremely critical of it; he pointed out inconsistency after inconsistency, cited the concepts of Aristotle, Plato, the Pythagoreans—indeed, he had the whole sum of astronomical knowledge both ancient and contemporary at his finger tips—and he had the happy faculty of making his pupil more and more sensitive to every weakness in the orthodox concept of the universe. It is impossible to say how far Brudzewski unwittingly pushed Copernicus in the direction of the heliocentric theory. The minute comparative study of the works of Brudzewski and those of Copernicus which was made by Ludwik Birkenmajer in his volume *Stromata Copernicana,* seems to prove

quite conclusively that the teacher, while unable to establish a more perfect system than Ptolemy's, had nevertheless pointed out so many faults and had sown so many doubts that Copernicus's reactions while still at Kraków might well have passed through surprise and disquiet to doubt, and finally to complete negation of the Ptolomaic geocentric system. Whether Brudzewski had consciously encouraged the young Copernicus in a positive direction toward the heliocentric system is doubtful, but he did fan into flame that spark of divine intellectual discontent which would not let his pupil rest until he had found the lever which liberated the earth and sent it spinning on its orbit around the sun.

In the meantime Copernicus studied drawing and painting for his own pleasure. After four years at the University he was obliged to leave, for his quite despotic uncle, the Bishop, had made him a canon of the Cathedral Chapter in Warmia. It must have been with sadness that Copernicus departed from Kraków. All through his later life, as his biographers report, he is said to have attributed whatever learning he had acquired to his stay at that University.

We next see Copernicus on his way to Italy to study law at Bologna, but he undoubtedly looked forward to continuing the astronomical observations and studies which he had begun at Kraków and which he was to make systematically all his life. At any rate he soon made the friendship of the professor of astronomy at Bologna, the temperamental Dominic Maria Novaro, "astrologus rarissimus." Copernicus must have devoted considerable time to his juridical studies, but the humanistic lectures of the famous Latinists and Hellenists then at Bologna are known to have occupied him nearly as much. Greek in particular absorbed him, and he learned it quickly.

Life in Bologna was certainly not without its other fascinations for Copernicus. When his brother, Andrzej, joined him in 1498, it seems they found Italian wine, women, and song to be a branch of a young humanist's education which should not be entirely neglected. In the autumn of 1499 they suddenly found themselves with their money all gone. Neither of them dared to write directly to their uncle, but the Kashub, Bernard Scultet, the plenipotentiary in Rome of their home Chapter at Warmia and friend of the stern bishop, interceded for them. The funds arrived with no questions asked, and there is no record of the Copernicus brothers having any further financial troubles in Italy.

When in 1500 Pope Alexander VI issued the Bull which invited all Christendom to Rome for the great jubilee, Copernicus, since he was already in Italy, naturally joined the huge crowds of pilgrims to the Eternal City. In the Rome of Pope Alexander VI and Caesar Borgia, however, there was much going on which the young astronomer was soon glad to escape. But he did remain in Rome long enough to give a public lecture on mathematics, his first and so far as is known, his only formal appearance as a professor.

Since medicine at this time was a science closely allied with astronomy and astrology, it is quite natural that Copernicus should have taken to it seriously in Padua, whither he now went. We are somewhat surprised that in this field his mind exhibited little of the far-ranging and original inquiry which distinguished it in astronomy. He did, to be sure, enjoy a high reputation as a physician in later life and was much sought after by church dignitaries and others in Poland for medical advice and treatment. He was, at the very least, an extremely conscientious physician. In the margins of one of his medical handbooks we have evidence that he reproached himself quite sternly for overdosing a patient with fairly dangerous medicine. Opposite a passage urging care in measuring dosages Copernicus jotted down "March, 1526, Remember what you did," and a little lower, opposite a practical suggestion that it is always best to make prescriptions as short as possible, he wrote "Remember this, doctor." Further marginal notations like "attention," "attention," "swiftly acting specific," "apply locally," "attention," all indicate that our astronomer did not himself quickly recover from the over dose he had administered to a patient.

After taking his doctorate in medicine at Padua and in Canon Law at Ferrara, he returned to Poland in 1504, and from then onward to the end of his life he assumed his active duties as a canon in the duchy-bishopric of Warmia.

One would expect his life as a canon to be leisurely, and to be devoted exclusively to the observations and computations necessary to establish the heliocentric theory which he had now definitely conceived. But he had little leisure. He was not only physician and personal secretary to his uncle, the bishop, but he was also administrator of the church property of the whole bishopric of Warmia and was obliged to travel throughout the entire region at regular intervals in the year.

The times were extremely tense in Warmia. Under the threat of attack by the Teutonic Knights of the Cross, the shy contemplative scholar was obliged to become a man of action. Copernicus organized the whole of Warmia for resistance. When the war did break out in 1520, the churchman, physician, and astronomer became commander in chief of the defences of Warmia, and from the fortified but beleaguered city of Olsztyn (Allenstein) he directed the defence so ably and successfully, that one must add "soldier" also to his list of titles. To "soldier" we should still be obliged shortly to add another—"economist." As early as 1519 he had elaborated a treatise on coinage which antedates by forty years Gresham's law on the behavior of debased currency. Nor is this the whole story of Copernicus's venture into economics. In his work as administrator of the church lands in Warmia after the ravages of the war he compiled a sliding scale of ceiling prices for bread based on the varying local prices of grain, and he normalized the weights and measures throughout the whole area under his jurisdiction.

All the accomplishments of Copernicus as a churchman, physician, economist, and soldier were on a level which may be called great. He showed great piety as a churchman, great conscientiousness as a physician, great realism as an economist, and great courage and boldness as a soldier. But as an astronomer all these qualities of piety, conscientiousness, realism, and boldness were intensified a thousandfold. The very vastness of the mathematical problem in Copernicus's conception of the heliocentric system would have stunned mere intellect alone. But in Copernicus, intellect was sustained by moral heroism, which in pious and humble pursuit of truth, dared to attack that problem, and dared to challenge the scientific tradition of centuries even though it was supported by the universal church of which he was a member. Copernicus realized that his own life-long observations and those of his contemporaries were not sufficient to establish the exact periods of the planetary revolutions. He knew he had to base his conclusions on centuries of careful observations of the heavens in order to note any variations, the least of which would have proved his hypothesis wrong. And in order to base his conclusions firmly, he had to collate the chronology of his own data with that of the observations made in classical and Biblical antiquity. In other words, he had to establish an accurate calendar by which all these observations over a span of twenty centuries could be brought to bear upon his mathematical problem.

In 1530, after a lifetime of labor, he had finished, and *De Revolutionibus Orbium Coelestium* was written. It was not published until 1543. The first printed copy, published in Nuremberg, did not reach Warmia until May of that year barely in time to be laid on the deathbed of the master.

This stupendous achievement was not only the culmination of Copernicus's own career as a mathematician and astronomer. It was also the rarest and most priceless gift to the world of the humanism which Poland first among the Transalpine countries had fostered in her culture at the University of Kraków. We all observe the year 1543 today as the beginning of modern science. Let us also remember the country whose son we are honoring. In the history of Poland's learning, of her free institutions, and of her Christian neighborliness, which I have but briefly touched upon, the publication of her great astronomer's book was also only the beginning of her own Golden Age of literature, and learning, and peace. Too few of Poland's friends know this. I should like, therefore, to regard our salute today to Copernicus, the astronomer, as also a salute to Copernicus, the soldier, and to the cause for which he, a churchman, bore arms,—the freedom, integrity, and culture of his people.

THE UNIVERSITY OF CRACOW IN THE TIMES OF COPERNICUS

By PROFESSOR R. TAUBENSCHLAG
University of Cracow, and Columbia University

In the second part of the fifteenth century Poland became one of the greatest powers of Eastern Europe. Politically ambitious, she became simultaneously a great center of culture, with Cracow as a focus of ideas and movements imported from the West, just as Prague in the preceding century.

At the head of these cultural ideas and movements was the ancient Jagiellonian University. In the last days of the fifteenth century scholasticism still held its own there; almost as if it could foresee its fate, it seemed to be drawing up the inventory of its scientific achievements, writing handbooks to popularize its methods and disciplines, commenting again on Aristotle and his commentators. Johannes Glogovius, the grammarian and astronomer, is the best representative of this epoch.

But that was the swan-song of scholasticism. It had to die in order to make room for new ideas heralded by humanism. What were the devices of the new movement?

Latin was the exclusive language prevailing in the middle ages, but it was corrupt. It was taught in hand books; the most popular of them was the *Doctrinale* of Alexander de Villa Dei. The commentators of Alexander added to the original written in verses a huge balast of notes, full of the subtilities of scholastic philosophy. They were partly taken from books called *"de modis significandi"* in which the medieval writers attempted to give a philosophical explanation of the meaning of words. These writers and their spiritual father Scotus, dominated the medieval teaching and cultivated the sc. *grammatica speculativa.* Laurentius de Valla was opposed to this method already in the XV century in his *"Elegantia linguae latinae"* and advocated the revival of the classical Latin; but the final battle against the *Doctrinale* was fought by the Italian grammarians. They conspired against Alexander's further

domination in the schools and they decided to remove him entirely. In the fight between the two parties the name *"Alexander"* became synonymous of barbarism, backwardness.

In contrast with scholasticism, the humanists appreciated highly the beauty of language and form; they tried to develop the beauty of the Latin language in innumerable oratorical and poetical compositions. They enjoyed its charm and tried to convey their feelings to others. There was a need for manuals in the field of *eloquentia,* which would present models for imitation. Consequently a humanistic literature developed consisting of textbooks for rhetorics, poetics, and epistolography, a literature which was enriched by all the famous representatives of humanism. But the humanists did not intend to restrict themselves to grammatical and rhetorical exercises; they decided to go back to the ancient authors. They called themselves *"poetae"* because they dealt with poets and ancient orators. These poets undertook the destruction of the antiquated medieval system of the Universities.

The forerunner of the humanistic movement in Poland, in the Jagiellonian University, was Grzegorz of Sanok who was the first to give lectures on the Bucolics of Virgil, revealing the beauty of these poems to his students; another scholar Grzymała developed a similar activity. These signs of a new epoch were followed by others; since 1487 lectures on classical works such as the *Aeneide* and *Metamorphoses* were delivered for the first time. At the end of the XVth century a wandering scholar, *Conrad Celtes,* came to Cracow, proclaiming the fight between the defenders of the old order called with contempt "sophists" and the advocates of the "new ideas," the humanists. The fight ended with complete victory of the humanists. This result finds its expression in the "directories" of the Universities where for instance we find lectures on Cicero in 1940, on Virgil and Horace in 1492, and in 1509 lectures on Plautus. In the catalogues the lecturers were called *"poetae";* such were *Paulus de Crosno* and *Rudolf Agricola.* Simultaneously we notice a turn toward the Greek language which was taught in the University since 1520. In this way humanism established itself triumphantly in the oldest Polish University.

Beside the study of Latin, another branch of human knowledge deserves attention. According to the medieval system of education a student who intended to obtain the bachelor's degree had to

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At the head of these cultural ideas and movements was the ancient Jagiellonian University. In the last days of the fifteenth century scholasticism still held its own there; almost as if it could foresee its fate, it seemed to be drawing up the inventory of its scientific achievements, writing handbooks to popularize its methods and disciplines, commenting again on Aristotle and his commentators. Johannes Glogovius, the grammarian and astronomer, is the best representative of this epoch.

But that was the swan-song of scholasticism. It had to die in order to make room for new ideas heralded by humanism. What were the devices of the new movement?

Latin was the exclusive language prevailing in the middle ages, but it was corrupt. It was taught in hand books; the most popular of them was the *Doctrinale* of Alexander de Villa Dei. The commentators of Alexander added to the original written in verses a huge balast of notes, full of the subtilities of scholastic philosophy. They were partly taken from books called *"de modis significandi"* in which the medieval writers attempted to give a philosophical explanation of the meaning of words. These writers and their spiritual father Scotus, dominated the medieval teaching and cultivated the sc. *grammatica speculativa.* Laurentius de Valla was opposed to this method already in the XV century in his *"Elegantia linguae latinae"* and advocated the revival of the classical Latin; but the final battle against the *Doctrinale* was fought by the Italian grammarians. They conspired against Alexander's further

domination in the schools and they decided to remove him entirely. In the fight between the two parties the name *"Alexander"* became synonymous of barbarism, backwardness.

In contrast with scholasticism, the humanists appreciated highly the beauty of language and form; they tried to develop the beauty of the Latin language in innumerable oratorical and poetical compositions. They enjoyed its charm and tried to convey their feelings to others. There was a need for manuals in the field of *eloquentia,* which would present models for imitation. Consequently a humanistic literature developed consisting of textbooks for rhetorics, poetics, and epistolography, a literature which was enriched by all the famous representatives of humanism. But the humanists did not intend to restrict themselves to grammatical and rhetorical exercises; they decided to go back to the ancient authors. They called themselves *"poetae"* because they dealt with poets and ancient orators. These poets undertook the destruction of the antiquated medieval system of the Universities.

The forerunner of the humanistic movement in Poland, in the Jagiellonian University, was Grzegorz of Sanok who was the first to give lectures on the Bucolics of Virgil, revealing the beauty of these poems to his students; another scholar Grzymała developed a similar activity. These signs of a new epoch were followed by others; since 1487 lectures on classical works such as the *Aeneide* and *Metamorphoses* were delivered for the first time. At the end of the XVth century a wandering scholar, *Conrad Celtes,* came to Cracow, proclaiming the fight between the defenders of the old order called with contempt "sophists" and the advocates of the "new ideas," the humanists. The fight ended with complete victory of the humanists. This result finds its expression in the "directories" of the Universities where for instance we find lectures on Cicero in 1940, on Virgil and Horace in 1492, and in 1509 lectures on Plautus. In the catalogues the lecturers were called *"poetae";* such were *Paulus de Crosno* and *Rudolf Agricola.* Simultaneously we notice a turn toward the Greek language which was taught in the University since 1520. In this way humanism established itself triumphantly in the oldest Polish University.

Beside the study of Latin, another branch of human knowledge deserves attention. According to the medieval system of education a student who intended to obtain the bachelor's degree had to

study the three arts (*trivium*), a commentary to Alexander, poetics, and Aristotle; in addition to that he had to acquire some astronomical and mathematical knowledge regarding the church-calendar and its holidays; he was taught the s.c. *Computus* and instructed in the s.c. *Sphaera materialis*. Natural science belonged therefore to the general curriculum of the Universities. The middle-ages had not made great progress either in mathematics nor in natural science. Mathematics lived on crumbs of the Greek science and were treated as a cinderella; the natural sciences were not favored by the spirit and the tendencies of those days. The cult for books dulled the scientific outlook regarding the surrounding reality and did not allow its investigation; not nature in itself, but books dealing with nature were the object of study; in these books old observations were mixed with the huge balast of the later commentaries. The medieval scholars searched mainly in the books of Aristotle for an explanation of the rules and mysteries of the universe. Therefore the professors lectured on his physics. Aristotle was the supreme authority and oracle in this field; the commentaries of Scotus and Albertus Magnus were supposed to be the key to his words, as he himself was that to the mysteries of the universe. In such circumstances any progress in the field of science was quite excluded. The dialectics played an important role in these studies; the physics of Aristotle was rather a philosophical book and led to philosophical commentaries. The only physical science in the medieval Universities were optics or perspectives, which were taught on the basis of the *Prospectus* of Pecham. In Cracow knowledge of it was required in examinations for obtaining the master-degree.

This system prevailed in the European Universities in general and also in Cracow. At Cracow some progress in mathematics may be noticed in the XV century due to the influence of Marcin of Zurawica, and in astronomy due to the influence of Wojciech of Brudzewo, astronomer and humanist, teacher of Copernicus. But the humanists had no influence on the development of this branch of science.

The registers of students throw some light on the scientific level of the University at that time and its attractive power for our own country and foreign lands.

The number of students in the last years of the XVth century increased considerably. In 1493 there were about 300 registered

students; in 1500 the number increased to about 500; in 1520 to about 1200. Their countries of origin were chiefly Poland, Silesia and Hungary, but also Germany and Switzerland. It is interesting to consider the statistics concerning the Hungarians. In the years 1493-1506 there were an average 28 Hungarians registered every semester; in 1526 their number increased to 138. As far as the Germans are concerned: in 1491 was enrolled Laurentius Bartholomaei de Novofori, that is, Laurentius Rabe or Corvinus of Neumarkt, who later became famous as a humanist; in the same year was also registered Sigismund of Breslau, well-known among the humanists under the name of Fusilius; among other students we have to mention Henry Bebel, who became later professor in Tübingen; Verdung of Hasfurt, who became professor in Heidelberg; finally Stephen Ressli, or Rosinus, who practiced mathematics and astronomy in Vienna. A whole series of German Universities were in this way provided with scholars, educated in Cracow. But above all excells the great name of the man registered in 1491, who moved the earth-ball's foundations, who achieved the greatest revolution on the earth and in the skies, whose name shines gloriously forever in the records of the University of Cracow, a name which overshadows all the others: it is *Nicolaus Nicolai de Thorunia.*

POLISH LITERATURE IN 1543

By PROFESSOR WACLAW LEDNICKI
Universities of Cracow and Brussels
Now at Harvard University

After the brilliant lectures about Copernicus and his work which we just have heard—I have not to emphasize the significance of the year 1543 for the whole world. For Poland and especially for Polish literature this year is also a very significant year. It is a year in which, in the first place, a very important literary phenomenon took place. This phenomenon changed completely the course of our literature, and for this reason we may consider the man who was responsible for it as the Copernicus of Polish literature. This man was Mikołaj Rey. But the reforms which he imposed on Poland in a sense followed a quite opposite road to that of Mikołaj Kopernik.

Rey was the author of the first book written in Polish—that is, it was with him that Polish literature abandoned the universal language, which was Latin, and adopted its national, Polish language.

It is necessary to stress that there was no other country at that time in Europe—with the exception of Hungary—which was so deeply, so completely Latinized as Poland was. Latin, once established, fascinated the Poles. As Nevill Forbes (University of Oxford) justly says: "If they wished to create anything which they hoped would have permanent value, anything, in fact, except that which they considered ephemeral and trivial—personal satires, facetious tales, epigrams and novelettes—they wrote in Latin, while works of grave import such as histories, political and philosophical disquisitions even memoirs, they continued to compose in that language . . . " [1] And all this in spite of the fact that Poles possessed already in the Middle Ages "extraordinary national vitality, which was symbolized then—says Forbes—as it is to-day, in the language . . . ," "this admirable medium of expression . . ."[2]

Everything was in Latin at that time—all instructions, acts, accounts, diplomatic correspondence of the King's Chancellery were

[1] *Polish Literature*—A lecture by Nevill Forbes, M.A.,Ph.D.—Oxford University Press. p. 9.

[2] *Ib.*

written in Latin. In the church—Latin was supreme. The judge, the prosecutor—were using Latin. The schools were under Latin rule also. The poets wrote in Latin. Even private letters, letters addressed to women—were written in Latin—Latin was a proof of culture, civilization, good education and good manners.

They knew also other languages. The result was that a great level of culture had been reached—so that the French historian, de Thou, who met some Polish nobles who came in 1573 to Paris to offer the Polish crown to Henry de Valois expressed his amazement: "Ce qu'on remarqua le plus, ce fut leur facilité de s'énoncer en latin, en français, en allemand et en italien; ces quatre langues leur étaient aussi familières que la langue de leur pays . . . Les Polonais parlaient notre langue avec tant de pureté qu'on les eût plutôt pris pour des hommes élevés sur les bords de la Seine et de la Loire que pour des habitants des contrées qu'arrosent la Vistule et le Dnieper, ce qui fit grande honte à nos courtisans qui ne savaient rien."[3])

This is a splendid testimony—and surely the knowledge of Latin, spread throughout the whole Polish-Ruthenian-Lithuanian Commonwealth, as well as the knowledge of European languages, acquired through many trips and voyages of Poles to Italy, Germany, France, England and to the Low Countries—enriched immensely our civilization and engraved in Polish minds universalistic ideals.

But for literature it was not very advantageous. In this respect Polish literature had been handicapped. No doubt that we had traditional folk-epics, folk-tales, ceremonial songs, which in other countries "form an inexhaustible mine of material for ethnographers and philologists". No doubt that we had all those "productions of popular imagination, anonymous creations handed on from generation to generation, elaborated and embellished by each in turn"—but perhaps "because they were not cherished . . . they fell an easier prey to the jealous and prudish censoriousness of the [church] hierarchy" — they vanished and disappeared.[4] "In the national language, unlike in Latin— there had been no continuity of development, no tradition," as Brückner says, speaking about Polish national literature. "The Polish literature of the first half of the XVth century—is an accidental collection of all sorts of translations—it did not have at that time any national character . . ."[5]

[3] H. Grappin, *Histoire de la Pologne,* Ed. Larousse, Paris 1922, p. 92.

[4] See Forbes, *op. cit.,* p. 10.

[5] See *Dzieje Kultury Polskiej,* v. II.

It is an amazing fact, but at the time when the French, the Italians, the Germans and even the Czechs already printed books in their national languages—in Poland the Latin book was the only one. Even as late as 1577 the great Polish historian Kromer wrote (he wrote in Latin of course) that "everybody is writing officially as privately—in Latin, because our language is neither as rich, nor as easy to read and write as other languages." In 1540 Decius says that "all Poles know Latin—but they do not write anything in their national language."[6]

In the XVIth century, however, the situation was already a little different:—Marcin Bielski, a historian, translated in 1535 the *Lives of Philosophers* from Czechish into Polish. In 1514 Ungler printed the first Polish book—*The Garden of Souls*—the translator was Biernat from Lublin, who gave to Poland his excellent *Aesop* and he might be considered the pioneer of the *Polish book.*

But the first writer who gave an *original* Polish book—written in Polish—was Rey—and this book appeared in 1543. (*Brief talk between three persons: a Lord, a Bailiff and a Curate*). It is a modest work—but enormously important for the history of Polish civilization. It is the first and even the only Polish satire which does not moralize in a dull, obtuse, heavy way. The author speaks sincerely, sharply, he gives a vivid and a bright picture of Polish life, of its vices, errors and sins.

All this is expressed in an excellent, picturesque, racy Polish language—not spoiled at all, not obscured by Latin—as Rey did not know Latin and did not consider Latin as the only decent language for the conveyance of serious information. He was a Pole born in the very depth of Polish Ruthenia, a Pole during his whole life deeply attached to Cracow and to the province of Cracow. He was a noble and an autodidact, who found himself among abecederians, doctors, priests and clerics—he knew the popular songs, proverbs—Polish and Ruthenian, he was a good tatter and chatter, ignorant, but realistic and full of human curiosity for anything which was human and true. He began to write dialogues in which he depicted life as he saw it—from those dialogues arose his *Brief Talk* of 1543, which opened a new era in Polish literature.

Immediately after him, after that year of 1543, in some 10-20 years appeared the most beautiful Polish poetical and prose texts

[6] See Brückner, *op. cit.*

which put the Polish national literature on a level equal to the best European texts of those times, enough to quote here Kochanowski, Sęp-Szarzyński, Orzechowski and Skarga—men who created a marvelous, rich, polished, elegant, penetrating language—such a language that when we read it now it is difficult to believe that it is almost 400 years old.

Rey was a Protestant and this is one of the most important elements and factors in this case. Because the Reformation—in spite of a very strange assertion of one of our famous historians, Professor Kutrzeba, who once advanced the opinion that the Reformation did not bring anything to Polish civilization — played an enormous role in the development of Polish thought, in the development of Polish social conscience and finally in the field of the evolution of the Polish language. Those who fought against Rome and the Church in Poland wrote Polish in order to be understood by the democratic masses of the Nation. "The Reformation—says Brückner —was a spring thunder storm which breaks the ice of the winter." From it flowed the torrents of Polish word and language—in some ten years, from 1550 to 1560 everything was changed: Latin had been finally overcome by Polish for ever.

In the same year 1543 there begun to write two great Polish writers: Andrzej Frycz-Modrzewski and Stanisław Orzechowski. The first wrote in Latin, the second in Latin and Polish; the first was a Reformer, defending Protestants, representing universalist ideals and a true Christianity in his writings as well as in his acts and life—the second, a nationalist and an orthodox Catholic, intolerant and intractable, author of a theocratic system, defending the predominance of the Church and of the Pope, but, at the same time, living a life full of disorder, of scandals, cynical and brutal, unfaithful, disloyal . . . but writing a wonderful Polish—one of the best in our history.

The first was one of the most idealistic, generous, wise, democratic Polish brains and hearts—one of the greatest Polish patriots —and just because of these features he, as it often happens, had been severely attacked by his contemporaries, the nobles of his time —blindly and jealously defending their privileges and abuses.

The second—flattering the human mob, his country, of which he is a panegyrist, full of cunning demagogy, a most repulsive, anarchic personality, but highly endowed with a brilliant literary talent, with a fantastic power of eloquence and expressiveness—Orzechowski

represents the classic Polish type of what might be the brilliancy of a Polish brain and at the same time of the degree to which arrogance and insolence, intolerance and fanaticism might reach.

Frycz and Orzechowski are two great Poles—but they are also two opposite poles of the Polish character and soul. Both belong to the Polish political and religious literature—and this literature is perhaps our greatest achievement in the XVIth century, this literature is the flower of our highly and prematurely developed political civilization. Indeed, there would be nothing more paradoxical and more astonishing than this parliamentary federative Commonwealth situated between the Muscovite Tsardom and the German Empire—at the moment when the Tsars of Moscow were organizing a formidable machinery of despotism and centralization and Prussia was preparing herself for her future imperialism and political depredation—the Poles were making of their Kings vanishing ghosts, becoming themselves citizens in an old Roman-Republican style.

The flower of that marvelous time and civilization was, as I said, our political literature, in which we may find beautiful monographs on the *Senator,* the *Diplomat,* the *Republic,* the *Courtier,* the *Government,* the *Monarchy*. . . .

Among all brilliant authors of that time, the first place belongs to Frycz-Modrzewski who so courageously, so wisely attacked all abuses, sins, vices, injustices committed by the nobles and by the clergy, and who so generously, being himself a noble, defended the suffering people, the peasants, the poor citizens deprived of all rights and privileges which were assured only to the nobles.

In his famous book *De Republica emendanda* he studies every field of public life, and the generosity of his altruism and the sincerity of his pacifism are really striking. He is emphasizing the necessity of equal laws for nobles and peasants, he is trying to elaborate a system of state protection for the unemployed workers, he is advancing the conception of international arbitration in order to avoid wars, he finally is developing the doctrine of a Christianized political life: the Christian law is obligatory not only for the individual but for the whole society, for all states, nations. . . .

He was fighting for the unity of the Christian world, defending the Protestants and the rights of the Eastern Church, he was fighting for the principle of a real Christian science against the arbi-

trariness of Rome and the abuses of the local clergy; he was defending the principle of equality of all citizens before the law and demanding a reform of legislation in order to establish such an equality; he was fighting for better material conditions of life for peasants and poor people as well as for some privileges for the burghers; he was fighting for freedom but he emphasized that there cannot be freedom without good laws. And when he was attacked by his contemporaries for his criticism of the country and the church —he explained that he did it just because of his great love and attachment for his country. "I would have great popularity if I would praise everything in our life—those who do not want to be criticized have to abandon their errors and sins; in order to oblige people to silence it would be necessary to pull out their tongues and abolish history."[7]

When we now read these authors—such as Modrzewski and Skarga—the Jesuit, who was our greatest preacher, we see the whole glory and brilliancy of our civilization — but we see, through their prophetic eyes also the terrible fate of this Polish Commonwealth—her tragic fate in the XVIII century, which has been in a great part the result of all those dangers, faults, errors and sins against which her most wise, generous and courageous spirits had warned the nation. There was established in Poland, owing to the atmosphere of the highly developed civilization of the Polish nobility of the XVI century, some general principles which ruled Polish political, religious, philosophical and scientific thought. —Let me quote some of them: *bonum publicum* which has to dominate every *rerum cognitio;* the *commodum aliorum*—as the real aim of every *studium in litteris ut et posteris etiam sciendum iter aperiret*—which is the aim of the real *sciendi cura;* in the study of law—*libertas sentiendi*—which means the normative faculty of definition; in history — *truth* — "soul of history," *prima historiae virtus—potissima ac propria cuiuscunque historiae laus*—which was expressed by Długosz and repeated by Kromer in this sense—that the law of historical truth obliges to take into consideration not only the good but also the bad characteristics of the people . . . and this in spite of the fact that "as the fatherland attracts us more and animates by its sweetness—*quoniam naturale solum magis allicit et incitat sui dulcedine. . . .*"[8]

[7] See Stanisław Kot: *Andrzej Frycz Modrzewski,* Kraków 1923, pp. 134-135.

[8] See Kazimierz Dobrowolski: *Studja nad kulturą naukową w Polsce do schyłku XVI stulecia, Nauka Polska,* Warszawa, 1923, v. XVII, pp. 17-148.

How could we not be grateful, deeply grateful to those great Poles for what they have done for the world and for their own country? They created, together with some of our great statesmen—such as Zamoyski, Tarnowski, the Kings Zygmunt-August and Batory,—a very special intellectual and moral climate in that peculiar Polish Commonwealth. Indeed this climate was not quite common and banal. It was a climate in which even the thoughts of an average Polish squire became amazingly elevated and idealist. Let me quote an example. After the death of the last Jagiellonian King Zygmunt-August there were several parties among the nobles organized for the expected election of the new King. There were several candidates to the Polish throne—among them Ivan the Terrible of Moscow. He had partisans—those who thought that a strong monarchical power would be of some utility for Poland. He had also adversaries. Polemics took place. One of the partisans of Ivan the Terrible wrote: "After the description of our laws and of our liberties it is impossible to believe that the King *sua naturali tyrannide aut rebellione* would be able to punish *sine suo periculo* anybody—in his property or in his life, because such are our laws and liberties. But if even such *leges et libertates* would not exist, the generous *magnanimitas* of the Polish nation should mitigate *etiam ferocissimam naturam principis,* because with our Lord the Sovereign we always have something *commune.*"[9] Yes, this conception *animi magnitudo* of the Polish nation, created by men like Modrzewski and deeply engraved in the Polish hearts, gave a special style to the Polish hearts—it gave a special style to the Polish national type and this type is still alive in spite of all deformations to which this type has been subjugated during the historical trials of the tragic existence of this so unfortunate, so terribly unhappy nation.

This *animi magnitudo* disarmed and appeased neither Germany nor Moscow, it did not disarm some Polish fanatical spirits either, but it gave, it assured to the whole Polish nation, the moral force to resist and hope, to live in faith in the final triumph of those universal ideas for which were and still are fighting the best men in the whole world.

[9] See: *Pisma Polityczne Z Czasów Pierwszego Bezkróleu:a,* ed. Jan Czubek, Kraków, 1906, p. 379.

THE PLACE OF COPERNICUS IN POLISH HISTORY

By PROFESSOR OSCAR HALECKI
University of Warsaw

When we turn from the darkest days of Polish history—those of our own time—to the brightest ones, which were the days of Copernicus, we do so not only to find some comfort in these recollections, but chiefly in order to study what certainly is the least known aspect of the Copernicus problem: the historical background of a scientific achievement whose outstanding importance is universally recognized, but which needs to be explained through a brief discussion of the contemporary conditions of life in the country where the genius of Copernicus was formed and found opportunity for such marvelous development.

If the Copernican era is called the golden age of Poland, this is usually for cultural reasons. But while Polish culture has made important contributions to European civilization even in periods of political crisis and foreign oppression, it must be remembered that the greatest of these contributions benefited very much from the harmony which then—and only at that time—existed between the strength and security of the Polish State and the cultural creativeness of the Polish people.

1473—the year when Copernicus was born—marks the height of Poland's political power. A few years before, in 1466, she had recovered her access to the Baltic Sea. The treaty was signed in the city of Toruń, where the Copernicus family, coming from Polish Silesia and for one hundred years established in Cracow, settled at a moment when the return of that whole region to the Kingdom of Poland had already been decided. At this time, Poland still possessed free access to the Black Sea, and a member of her dynasty had recently been elected King of Bohemia, to become later also the King of Hungary. The federal system of the Jagellonians included East Prussia as a Polish fief, first held by the Teutonic Order which Copernicus considered a most dangerous neighbor, and later by a branch of the Hohenzollerns, whose future rise to power was not anticipated by the Copernican generation.

Within the federation created in the fourteenth century by Polish-Lithuanian cooperation, various nationalities were peacefully living together. This explains why the Koperniks, themselves of Polish stock, had friendly relations and ties of kinship with families of German descent dwelling in the same towns. For townsmen were the ancestors of the astronomer who, in spite of his modest middle-class origin, occupied high official positions in a country where the gentry were predominant, indeed, but where the relations between the various classes of society still were fairly well balanced. During the youth of Copernicus, the Polish Diet, one of the oldest parliaments of Europe, was finally constituted, and in the last years of his life it started a democratic reform movement which not only to a large extent settled the national financial problems, so carefully studied by Copernicus, but also established full religious tolerance in a community where Copernicus, himself a canon of a Roman-Catholic diocese, witnessed the rapid though ephemeral spread of the Protestant Reformation.

But while the political and social environment contributed only indirectly to the formation of the scholar's mind, the education he received laid the very foundation of his greatness. He studied first at the already famous University of Cracow, where he was fortunate enough to find distinguished teachers in the field of astronomy and, of scarcely less importance, a general atmosphere of humanistic culture which made that Polish institution a truly European center of learning, attracting professors and students from many foreign countries. Of these countries, Italy had the closest cultural relations with Poland throughout the whole Renaissance period, and it was there that Copernicus continued his studies during the only years which he spent abroad. After his return home, he must have noticed a new trend towards intellectual cooperation on an even larger scale which included France and England, as well as the steady progress of Italian influence. Particularly conspicuous in the beautifully reconstructed royal castle on Wawel hill, the Italian influence was by no means limited to the artistic sphere: it was part of a development which after Copernicus himself, is perhaps the most striking contribution of Poland to the growth of European civilization—the creation of a type of culture which was at the same time Slavonic and Latin.

This process materialized under the long rule of a king whom Copernicus called his most gracious lord. Sigismund I was less of

a political leader than his father, during whose reign the astronomer was born, and less of a diplomat than the son who succeeded him soon after Copernicus' death. But for that very reason the peaceful humanist and patron of arts and letters, who occupied the throne for 42 years, is inseparably linked to the great scholar whose advice he appreciated. So also is the queen of Italian origin, Bona Sforza, another tie between the home land of Copernicus and that of the Renaissance. Humanists also, and deeply interested in cultural and educational progress, were Poland's greatest statesmen of these years, the chief collaborators of the king not only in politics, but also in his enlightened patronage. Thanks to this Copernicus, while needing no patronage for himself, was surrounded by contemporaries and intimate friends—among them the chief historian of the period— whose achievements, without reaching his unrivaled standard, make us realize that he was in no way isolated in his country or generation.

1543—the year of Copernicus' death, of the publication of his revolutionary book, and of the birth of modern science—was at the same time the year of the maturing of Polish literature if not of its birth. It is perhaps more than a fortuitous coincidence that three leading representatives of the next equally brilliant generation published their first works in that same year. One of them, Andrzej Frycz Modrzewski, a great political writer and social reformer, belongs, like Copernicus, not only to Poland but to Europe, where he was well known in the XVIth century, although now his name is almost forgotten outside his country. The same can be said of the great poet Jan Kochanowski, born 13 years before the passing of Copernicus. And just one year before the date we are commemorating, Jan Zamoyski was born, a great statesman who, educated in Padua like Copernicus, was at the same time a great humanist and a distinguished educator, and who has recently been described by an American as the most typical representative of Polish culture.

These few examples, illustrating the varied achievements of the Copernican era in Poland, indicate also the continuity of its tradition, long after 1543. Even Poland's cultural and political reform movement on the eve of the partitions was a conscious revival of her Golden Age, in spite of an interval of almost two hundred years and a century of cultural stagnation in the second part of that intermediary period.

Therefore it is not in any way artificial to connect the Copernican Quadricentennial, celebrated in May 1943, with another anniversary which is celebrated by the Poles every year in the month of May: the commemoration of the Polish Constitution of May 3, 1791. As the discovery of Copernicus marked the highest point of our Golden Age under the Jagellonians, so the May Constitution was the climax of our national revival under Poland's last king. And just as the importance of the first of these two achievements is recognized even by those who are inclined to neglect all the other Polish contributions to universal culture, so also is the second one considered a real progress even by the most severe critics of Poland's constitutional development.

Both cases, however, are much less exceptional and isolated in Polish history than they might appear to a superficial observer. Both are inseparable from the general atmosphere of Polish life, either in the fifteenth and sixteenth, or in the last quarter of the eighteenth century. And there is between these two periods of our history, different as they are in many respects, an unquestionable link of continuity.

One of our greatest political writers of the years preceding the May Constitution, Stanisław Staszic, gave expression to the far reaching reforms which he advocated, in the form of "remarks" about the life of Jan Zamoyski, who had shaped the Polish Constitution two hundred years before. The educational reform accomplished between the partitions, in intimate connection with the political and social reform, restored the activities of the Jagellonian University, the school of Copernicus, and the University of Wilno, founded thirty six years after the death of the astronomer. Great scientists, like the two Sniadeckis, soon resumed there his scholarly tradition, while the reborn historiography of the same generation collected, thanks to Adam Naruszewicz, the records of a development uninterrupted for more than eight hundred years.

Politically, this development seemed to be interrupted a few years later through the dismemberment of the first Polish Republic, although even in this field Poland's participation in the Napoleonic Wars, and her insurrections and independence movement in the following century, maintained the continuity of national life to a very large extent. Socially, the progress of Polish democracy, which can be traced back to the days of Copernicus and found such a strik-

ing expression in the Constitution of 1791, continued under foreign rule, in spite of oppressive forms of government imposed upon the partitioned nation.

But it is in the field of culture, which had been Copernicus' main concern, that the continuity of Polish life throughout the partition period is particularly conspicuous. What had been started under the last king of Poland, was developed under the most unfavorable circumstances, at times even in exile. And looking back to a Golden Age where our poets of the Romantic period saw their predecessors, our scholars of the nineteenth century found their highest inspiration in the memory of Copernicus. At the beginning of that century they placed his monument in front of the headquarters of the Warsaw Learned Society, and, at the end of the same century, in the middle of the ancient court-yard of the Library of Cracow University.

The same Copernican tradition remained a source of inspiration after the First World War when Poland's liberation seemed once more to create for Polish culture conditions as favorable as those which the great astronomer had enjoyed in his life time. He would have rejoiced in the general progress of sciences and learning in the restored Republic, a progress which was notable in his beloved field of astronomy and truly outstanding in the closely connected field of mathematics, as well as in two other sciences which during the last decades proved particularly successful in their discoveries: physics and chemistry.

But what would he say if he could see the present ordeal of all Polish centers of research, and, what is more than a symbolic detail, the attempted annexation of his own name and glory by the nation of the invaders?

The present situation in Poland is more than an interruption of cultural progress and something worse than a cultural setback. It is a catastrophe without precedent in the history of European civilization, so great that only the greatness of Copernicus' discovery can distract our mind and make it turn to the harmony of the heavenly spheres, undisturbed by human crimes, where eternal love is moving the sun—center of the Copernican system—and the other stars, discovered or undiscovered by his successors in all ages and all nations.

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COPERNICUS

1473 - 1543

By A. Vibert Douglas

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THE life span of Copernicus covers a period in history filled with movement in many spheres of human endeavour. It was an age of intolerance and reaction on the one hand and of high adventure and daring on the other.

It was the time when Michelangelo was at work in the realm of art; when Martin Luther was breaking with traditional theology and fighting for freedom of thought and conscience in the realm of religion; when Paracelsus was vitalizing mediæval medicine and Vesalius was making of anatomy a modern science. It was the time when the Moors with their rich Arabic learning were being pushed out of Spain, while Italy, the main centre of European scholarship, was gradually awakening from an intermittent sleep of twelve centuries. It was the time when Christopher Columbus was sailing uncharted seas to discover the islands of a new continent. It was at this time that Copernicus turned his back upon the ancient cosmologies and gave the world the heliocentric model of the Universe.

In the thirteenth century the Teutonic Knights had founded the town of Torun or Thorn near the mouth of the Vistula. This became an important trading port of the Hanseatic League. From Cracow, the chief town of Poland, a prosperous merchant named Niklas Koppernigk moved to Torun, married the daughter of a Polish-German merchant of that town, and in 1473 their fourth child, Niklas, was born. This boy grew up to become one of the makers of modern thought. When he reached the stage of productive scholarship, he followed the custom of the scholars of his day by publishing his works in Latin, and like so many of them he Latinized his name as author. Thus we know him not as Niklas Koppernigk, but as Copernicus.

COPERNICUS, 1473-1543

The education of Copernicus was long and varied. From the school of Torun he went to the University of Cracow in 1491. Here he found a strong school of mathematics and astronomy and no doubt studied the only two cosmologies that had survived the centuries since the rich speculative and mathematical period of Greek science. The simple Aristotelian system was based upon the geocentric universe of Pythagoras. The more complicated Ptolemaic system was built upon the ingenious work of the great Greek geometers who used circles and epicycles to reproduce the apparent motions of sun, moon and planets. While the Earth was not placed at the centre of these circles, it was still within the circles of all the heavenly bodies, and thus sun, moon, planets and stars moved around it.

In 1496 Copernicus went to Bologna where he worked at the school of law for four years. Here too he found astronomical interests in the observations and theories of the professor of astronomy, a brilliant man with an independent, critical mind, a leader in the current revival of Platonism. Copernicus next went to Rome where he took private pupils in Mathematics, but a year later he resumed his legal studies at Padua. Here he also studied Greek and began his wide reading in Greek science which led to his discovering for himself the half-forgotten speculations of Heraclides, Ecphantus and Hicetas on the axial rotation of the earth, and the heliocentric system of Aristarchus of Samos. This last was indeed a forerunner of the great scientific life-work of Copernicus, but it had been backed up in the third century B.C. by not one logical argument based upon astronomical observation which could overthrow the amazing partial success of the elaborate systems built upon the epicycles of Eudoxus.

Leaving Padua, Copernicus went to Ferrara where in 1503 he obtained his doctorate in Canon Law. He then returned to Padua and applied himself to the study of medicine

until the end of the year 1505. In the meantime his uncle, the Bishop of Varmia or Ermland, had succeeded in getting this scholarly nephew elected to a canonry at Frauenburg Cathedral. This appointment imposed no obligation to advance in ecclesiastical position beyond the first vows necessary for admission, and beyond this first stage Copernicus never went although he remained a member of the Chapter until his death thirty-seven years later.

For six years after taking up his residence as a Canon of Frauenburg, Copernicus served as medical attendant upon his uncle at the Bishop's palace which was the castle of Heilsburg. Here he was able to devote time to astronomical pursuits as well as to exercise the art of healing amongst the ecclesiastics and the poor of the diocese, on one occasion being summoned to Königsberg by the Duke of Prussia to attend a high official in his grave illness. At this time, too, he became experienced in political and administrative work. Varmia was trying to maintain a measure of independence with the powerful Teutonic Knights on three sides and Poland on the fourth. The Bishop had many problems arising from a population partly German, partly Polish, within his own principality; and also in neighbouring West Prussia where he was asked to mediate in the racial dispute. Copernicus carried out diplomatic missions for his uncle and after the Bishop's death he was entrusted with the temporal and spiritual administration of the remoter parts of the diocese. Later when war developed between Poland and East Prussia involving the would-be neutral territory of Varmia with bombardment, raids and pillage, Copernicus proved himself the strong man with high qualities of leadership and practical foresight. At the peace conference following the 1521 armistice it was Copernicus who presented the claims of Varmia for war damage.

The coinage of the Prussian states, already debased before the war, now presented very serious problems, both internally

and in neighbouring states. Copernicus placed before the local diet a scheme for monetary reform, and in a report published first in German and later in Latin he set forth his plan for recoinage and enunciated what later became known as Gresham's Law.

During these years with their multifarious duties, Copernicus had laid the foundations of his planetary theory and written the first draft of *De Revolutionibus Orbium Coelestium*. He had used the primitive instruments then in vogue to make observations upon some of which the arguments in favour of his theory were based. He had published accounts of the construction of a meridian quadrant and of a Ptolemaic astrolabe. One work only of a purely literary character came from his pen. It was his Latin translation of the Greek Epistles of the poet Simocatta, published in Cracow in 1509 when he was in that city on diplomatic business.

For six months in 1523 Copernicus was the Administrator-General of the diocese. Then a new Bishop was appointed and thereafter Copernicus was less burdened with the affairs of the world about him and could give closer attention to the astronomical problems which had absorbed his thoughts for so many years. Peace had come to the land with the triumph of Poland over the Teutonic Knights; but there could be no peace in the minds of thinking men and seekers after truth. Intolerance was growing and was soon to reach new peaks of viciousness in defence of orthodoxy against the teachings of Luther and against any scholarly work that cast a shadow of doubt upon that amazing synthesis, by St. Thomas Aquinas and other Church Fathers, of Judaic thought, Christian doctrine and Greek philosophy and science.

In the years 1523-32 Copernicus revised the manuscript of his great book, but apparently he made no attempt to publish it. It was known to exist, however, but only a very few

scholars had the vision and the courage to be openly interested. In 1536 Cardinal Schönberg of Capua wrote to Copernicus as follows:

Having constantly heard of your talent, I have begun to honour you more fully, and to congratulate our countrymen amongst whom you have flourished with so great renown. For I had perceived that you were not only well versed in the works of the old mathematicians, but also had propounded a new theory of the universe. By it you teach that the earth moves, that the sun is at the bottom of the universe, and indeed holds the middle place. That the eighth heaven remains immovable and eternally fixed. That the moon, with the elements included in her sphere, placed between the heaven of Mars and Venus, revolves in a yearly course round the sun. And that you have written commentaries on this whole theory of astronomy, and have reduced into tables the motions of the planets, computed from calculations, to the great admiration of everyone. Wherefore I beseech you, most learned man, if I am not troubling you, to impart this your discovery to the learned, and also to send to me in the first place your lucubrations concerning the sphere of the universe, with the tables, and anything else you have pertaining to the same matter. And if you will gratify me in this, you will find that you have to do with a man careful of your name, and one anxious to do justice to such great talent. Farewell. At Rome, Calends of November, 1536.

In 1539 a youthful German professor of mathematics came to visit Copernicus at Frauenburg. His name was Joachim von Lauchen, alias Rheticus, and as he was one of Melanchthon's men from the Protestant University at Wittenberg, not only was he running a risk himself remaining in an atmosphere of latent hostility and suspicion, but his presence inevitably focused suspicion on Copernicus. Nevertheless the Canon of Frauenburg welcomed Rheticus, expounded his cosmology, encouraged him to summarize the manuscript and to publish the summary in Danzig in 1540. On his next visit Rheticus

summarized the chapters dealing with plane and spherical trigonometry which Copernicus had brought together and generalized from the works of Ptolemy, and these he published at Wittenberg in 1542.

Copernicus had obviously withheld his book lest its publication should lead to open opposition to his investigations, but he now wrote to Osiander, a Lutheran theologian and an able mathematician, asking him whether in his judgement the work would give offence. Osiander's reply dated April 20, 1541, is in part thus " . . . I have always felt about hypotheses that they are not articles of faith, but bases of calculation. . ."

Copernicus, now nearing seventy years of age, at length determined to publish his completed work. He inscribed his Preface "To the Most Holy Lord Pope Paul III", Osiander wrote an anonymous foreword, and Rheticus arranged that the book should be printed at Nürnberg. Soon after this Copernicus was stricken with paralysis from which he never recovered though he lingered on for a few months. On May 24, 1543, the first copy of *De Revolutionibus* was received from the publishers. It was placed in his hands. He saw it and was glad. A few hours later Copernicus was dead.

Four hundred years ago the words of Osiander supplied a temporary and partial camouflage for the dynamite which the book contained. Copernicus had written,

First and above all lies the sphere of the fixed stars, containing itself and all things, for that very reason immovable; in truth the frame of the universe, to which the motion and position of all other stars are referred. Though some men think it to move in some way, we assign another reason why it appears to do so in our theory of the movement of the earth. Of the moving bodies first comes Saturn, who completes his circuit in xxx years. After him, Jupiter, moving in a twelve year revolution. Then Mars, who revolves biennially. Fourth in order an annual cycle takes place, in which we have said is contained the earth, with the lunar orbit as an epicycle. In the

fifth place Venus is carried round in nine months. Then Mercury holds the sixth place, circulating in the space of eighty days. In the midst of all dwells the Sun. Who indeed in this most beautiful temple would place the torch in any other or better place than one whence it can illuminate the whole at the same time? Not ineptly, some call it the lamp of the universe, others its mind, others again its ruler–Trismegistus, the visible God, Sophocles' Electra, the contemplation of all things. And thus rightly in as much as the Sun, sitting on a royal throne, governs the circumambient family of stars. . . We find, therefore, under this orderly arrangement, a wonderful symmetry in the universe, and a definite relation of harmony in the motion and magnitude of the orbs, of a kind which it is not possible to obtain in any other way. (*De Revolutionibus*, Bk. I, Chap. X.)

"In the midst of all dwells the Sun." He postulated three motions of the Earth, (i) a diurnal rotation from west to east about the polar axis; (ii) an annual revolution about the Sun in the plane of the ecliptic; (iii) a variation in inclination of the Earth's axis to the line joining Sun and Earth. Thus he explained the apparent daily rotation of the heavens, the apparent annual motion of the Sun through the constellations of the Zodiac, and the cycle of the seasons. He discussed the motion of the moon as a satellite of the Earth. He dealt with the motions and relative positions of the two inner and three outer planets, explaining their siderial and synodic periods. He affirmed the extreme distance of all the stars, so great that the Earth's orbital motion produced no apparent parallactic shift of the stars. All this was elaborated with diagrams and position tables, and a weight of evidence so great as to leave no careful reader of *De Revolutionibus* with any vestige of doubt but that Copernicus intended his heliocentric planetary theory to be regarded as a statement of physical fact.

Small wonder, then, that when the far-reaching significance of this book was realized timid, bigoted and intolerant

ecclesiastics denied its implications and discouraged the study and discussion of its arguments by threat of torture and the stake. It was not, however, placed upon the Index until 1616, but there it remained until 1835.

William Gilbert in England and Giordano Bruno in Italy, both born in the 1540's, became the first notable men outside central Europe to convince themselves that a new light had dawned in astronomical thinking, and a new universe lay open to the eyes and minds of men. Gilbert advocated the Copernican theory and lived to publish his famous *De Magnete* and to die in 1603 respected and honoured in Elizabethan England. But Bruno's advocacy of the same theory placed his life in jeopardy. He escaped from Italy and proceeded to expound the Copernican cosmology and his own somewhat pantheistic but rather beautiful philosophy in Geneva but fled the intolerant disapproval of Calvinism. In Paris and later in Oxford and in Wittenberg he discoursed upon the new theory, being generally opposed but arousing interest in it wherever he went. Lured back to Italy on a promise of freedom to think and teach what he believed true, this scholarly disciple of Copernicus in science and of von Cues and Ramón Lull in philosophy went to the stake in Rome in 1600 for his advocacy of new ideas.

Sixty years later Galileo placed the Copernican Theory on so firm a footing of new astronomical observations that his name stands linked with those of Copernicus before him and Sir Isaac Newton following him at this great turning point in the history of human thought.

Thus Copernicus and his book ushered in the renaissance of learning in astronomical science. During the four hundred years which have followed, knowledge has grown from more to more. Copernicus had displaced the Earth from the centre of the Universe and man's abode had become a minor planet.

In a later century the Sun and planets were removed from a central position in the stellar universe to an inconspicuous place more than half way out along a radius of the Milky Way system. In our own century our galactic system has become only one of many million stellar galaxies. Circles gave place to Kepler's elliptic orbits three centuries ago. Nothing now remains static, neither earth nor sun nor stellar galaxy, not even the framework of space itself in the Lemaitrian speculations of our own times.

The repercussions of the Copernican cosmology upon philosophy were inevitably far reaching, though Copernicus himself seems not to have realized the full implications of his work in this respect. It was his great successor, Galileo, who boldly drew the inferences—if a geocentric cosmology had to be abandoned, anthropocentric philosophy must likewise go. Henceforth the man of science must investigate nature with complete objectivity. Philosophy must break away from the shackles of teleology focused upon man. Man was no longer obviously of prime importance as had been so easy to assert in the ancient world with its geocentric outlook. For man the sun and moon rose and set, for him the stars shone forth, for him the rains fell and the earth produced her increase—"Thou madest him to have dominion over the works of Thy hands, Thou hast put all things under his feet." If to-day man be regarded as of great intrinsic worth, it is not because this is an inevitable deduction from a survey of the physical universe, it must be for intellectual and spiritual reasons. Such reasons, happily, are not wanting when we study the character, achievements and influence of such men as Copernicus, men filled with courage and with "the divine afflatus of the truth-seeker".

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Newton Tercentenary

Speech by SIR ARTHUR EDDINGTON

ABOUT TWO HUNDRED AND EIGHTY YEARS AGO there was a youth working on a farm, who was so incompetent a farmer that his guardians decided he was only fit to be sent to Cambridge University. To-day he stands unchallenged as the greatest genius in science; and you, the Professors, Lecturers, and Engineers of a far country, have laid aside the anxieties which have fallen so heavily on you to do honour to his Tercentenary. It is a great pleasure to have been invited to be with you on this occasion. As a member of Newton's College and a Professor in his University, I feel almost as if I were representing him and might return thanks to you on his behalf. I do not occupy his professional chair; that is held by Professor Dirac. But almost daily I pass the rooms where he laboured at his calculations and carried out his experiments. Perhaps also I may speak as a representative of the modern scientific spirit—that is busy in demolishing and rebuilding the system of science which Newton left us. At least there have been times when I have had the reputation of being a revolutionary; but it is even truer in science than in politics that a revolutionary has to go ahead very fast indeed if he is to avoid being overtaken by respectability. Speaking for the modern spirit in science, we are not behind the others in our veneration for Newton—who was in his day a greater revolutionary than any of us. If to-day we are able to see farther than our predecessors it is because we stand on their shoulders; and I am afraid they cannot help getting a few kicks as we scramble up—not even Newton excepted. Our turn to get kicked will come all too soon.

Newton has left us a problem perhaps more baffling than the scientific problems which he mastered so superbly—the problem of his strange personality and his strange genius. How was it that the solitary voyager in far seas of thoughts, who took no trouble to make his ideas comprehensible or even to publish his discoveries—a man whom one would have expected to be unappreciated until years after his death—was almost instantly recognized by his contemporaries as an outstanding genius? How was it that a character, whom all accounts make out to be rather ungracious, secretive, and without any endearing human traits to soften his rigour, nevertheless attracted warm and steadfast friends who displayed the most unselfish devotion? I have listened to several addresses on Newton recently, but I still feel unable to form a picture which can possibly represent him as he must have appeared to his contemporaries. Surely there must have been some charm, some magnetism, some power of personality, the memory of which has not been handed down.

To you, gentlemen, Newton stands in a special position because he comes at the end of a line of which your own Copernicus was the beginning. Copernicus, Tycho Brahe, Kepler, Galileo, Newton are a line of kings of science leading from mediaeval to modern thought. Of the way in which Newton dispelled the last mists of mediaevalism, and laid the foundation of order on which modern science is built, you will doubtless hear in the lecture that is to follow.

> Nature and Nature's laws lay hid in night.
> God said, 'Let Newton be!' and all was light.

In the forefront of Newton's scientific work we must put, as I think he himself would have done, his study of gravitation and of light. They seem entirely detached subjects; but in his *Optics* Newton suggests one connection: 'Query 1. Do not Bodies act upon Light at a distance, and by their action bend its Rays, and is not this action (*caeteris paribus*) strongest at the least distance?' That query remained unanswered for more than two hundred years. In 1919 it fell to me to lead one of the two eclipse expeditions which answered it. The other expedition had better weather and obtained more accurate results; but circumstances delayed their reductions. I well remember my feeling as I completed our own reductions—realizing that I was the first to know that the question put by Newton so long ago had received the answer Yes.

Let me conclude with an example of the way in which the modern physicist regards Newton. Twenty years ago I was in Einstein's study in Berlin, and I noticed that there were four portraits hanging on the wall. First came Newton, then Faraday, then Maxwell. And the fourth was another portrait of Newton.

The Distortion of History

The British National Committee of the International Congress of Historical Sciences invited a second conference of historians of allied nations to Cambridge on the 19th to 22nd March, 1943. This conference was devoted to the problem of the distortion of history made by German historiography in the last decades. The conference was held in King's College, Cambridge, and the Vice-Provost, Sir J. Clapham, presided. Many representatives of British Historical Sciences and representatives of six allied nations took part in the conference. Poland was represented by: S. Glaser,

O. Gorka, Major O. Laskowski, Z. Obertynski, P. Skwarczynski, G. Sulimirski, and A. Zoltowski. The conference was opened by an address by Professor Barker, Cambridge, on the general tendencies of German historiography, and the speaker underlined her imperialistic tendencies as well as the indeterminism and variability of aims. This and following talks by Professor Vaucher (on the distortion of French history by the Germans) and by Dr. G. Opocensky (on the distortion of Czech history) were all three followed by a very vivid discussion. The afternoon began with a talk by Major Laskowski, who concentrated on the rectification of all the distorted facts published in the recent work of the German historian Brockman. The conference finished with an excellent talk by Professor Bokhorst, who showed how even Dutch history was used for German purposes and falsified.

The conference gave more than it promised to give. Many important facts were brought forward by the representatives of British history and representatives of the other nations. It was shown that observations coincided and that the same methods were found by different people to be applied in German scientific publications and in the way of teaching. German historiography has followed one great aim and adjusted its organization to that aim—to distort the picture of modern Europe. Nevertheless, it was emphasized amongst historians taking part in the conference that this is rather a sign of newer Germany—very different from the much higher level of German historiography in the nineteenth century. There were also tendencies but not open falsification of truth for political reasons. All these points were brought out in a last speech closing the conference by Sir J. Clapham.

The organization of the conference was excellent, thanks to the energetic initiative of Mr. H. Butterfield of Peterhouse College and Miss H. M. Cam.

Conference of Ministers of Education of Allied Governments now in London

THIRD MEETING, MARCH 16, 1943

THE THIRD MEETING of this Conference, under the Chairmanship of Mr. R. A. Butler, M.P., President of the Board of Education, was held at the Offices of the Board, Belgrave Square, on March 16th. The First Meeting of this Conference was held in October and the second in January. The Conference was established by Mr. Butler in co-operation with the British Council after consultation with the Foreign Secretary, for the purpose of considering the educational needs of the Occupied Countries after the war. The Meetings are attended by the Ministers of Education of all the Allied Governments established in the United Kingdom, by representatives of the French National Committee, and also by representatives of the British Council, the Scottish Education Department, and the Foreign Office. The British Council provide the Secretariat.

It should be noted that the Conference is concerned chiefly with the needs of occupied Europe. This does not mean that contact will not be maintained with the U.S.A., the U.S.S.R., China, and the Dominions.

The following matters were among those discussed.

1. *Treaties of Understanding between the Allied Nations.* The Conference considered a report submitted by M. Jules Hoste, Under-Secretary of State to the Belgian Education Department, who at a previous Meeting had been appointed Chairman of a Commission to consider the drafting of a model Cultural Convention. The report showed that a number of such Treaties had been concluded between the Governments of various countries before the war, in some cases by the Axis countries for their own ends. The main basis of Treaties of this kind, however, as envisaged by the Conference, would be collaboration in the educational field with special provision for the interchange of teaching staffs, the encouragement of studies in each country of the culture of the other, and the mutual recognition of examinations and degrees. Such a Cultural Convention would, it was agreed, without encroaching on the political or economic field, form a method of drawing nations together and would form a positive contribution by the democracies for post-war unity.

No final conclusion has yet been reached, and further consideration is to be given to the detailed recommendations of the report.

2. *The Supply of Books and Periodicals to the Occupied Countries after the War.*

The Conference considered an interim report from the Commission appointed two months ago under the Chairmanship of Professor Ernest Barker. The Deputy Secretary-General of the British Council is Secretary to this Commission and delegates have been nominated by each of the Allied Governments concerned. The report shows that the Commission have already held several meetings and are concentrating their inquiries in the first instance on the problem of replenishing the National Libraries of the occupied countries and are proposing to give special attention to the question of textbooks for the schools.

3. *The Preparation of a Brief History of the War.* It was agreed that it would be desirable to consider the preparation of a brief history of the war primarily for use in the schools, showing clearly and simply the objects for which all the United Nations are fighting. A general desire was expressed to have some factual statement of the manner in which the citadel of Europe was attacked and destroyed by the enemy. It was important that it should be a simple historical account of events showing by what methods the enemy extended his grip on Europe and describing the shape of European civilization before the enemy's attack, which would also form a structure on which to build after his grip was broken.

At earlier Meetings of the Conference the matters discussed included the various ways in which the Board of Education, the Scottish Education Department, and the British Council

for many years right round the heavens, according to a well-defined plan. These observations made it possible for the first time to find out what kind of orbit would best satisfy the observed places of a planet. It had always been assumed that the planets could only move in circular orbits or in orbits resulting from combinations of circles. After many years of investigation of Tycho's observations, Kepler (1571–1630) published in 1609 his book, *De Motibus stellae Martis*, announcing his discovery and proof of the elliptical orbit of Mars around the sun, which was destined to cause the final disappearance of eccentric and epicyclic circles. This remarkable discovery would not have been possible, if Kepler had not accepted the heliocentric theory. It perfected the system of Copernicus and all that then remained to be done was to prove that the motion of the earth was physically possible and to explain why the earth and planets moved in accordance with the laws that Kepler had enunciated. In the same year, 1609, Galileo constructed his first telescope. In 1610 his discovery of the satellites of Jupiter was announced in the *Sidereus Nuncius*; in 1611 he observed the phases of Venus and Mercury and also discovered sunspots and the rotation of the sun, which he announced in 1612 in the *Discorso* and more fully in 1613 in the *Istoria e dimostrazioni*. These observations of Galilio made it seem probable by analogy that the earth rotated on its axis and that, with the other planets, it revolved around the sun.

When the attack on Galileo was made by the Catholic Church, the *De Revolutionibus* was placed on the Papal 'Index' in 1616 and declared heretical. The book was only allowed to be read provided that all passages referring to the motion of the earth were altered to assert that this idea, though false, was introduced merely as a mathematical hypothesis to simplify the calculations. The Tychonic system, unlike the old Ptolemaic system, could be reconciled with these new discoveries, and it remained as the only serious competitor to the Copernican system, though it was generally modified to admit of the rotation of the earth. Nevertheless, by the end of the seventeenth century, the Copernican system had finally displaced the Tychonic system. This was not because direct observation had provided any confirmation of the Copernican system, but because the heliocentric system was better adapted to the physical and mechanical explanation of the planetary motions. It fitted in naturally with Newton's mathematical demonstration of Kepler's laws of planetary motion in terms of universal gravitation. Observational proof of the revolution of the earth round the sun was eventually provided by Bradley's discovery of aberration, announced in the *Philosophical Transactions* of 1729. The first definite detections of the annual parallax of a fixed star came long afterwards and were announced almost simultaneously by Bessel in 1838, by Henderson in 1839, and by Struve in 1840. But the Copernican system had become firmly established and universally accepted long before these observations had proved its truth. With its acceptance, the conception of a small geocentric universe had finally to be abandoned and a profound revolution in human thought and outlook had been accomplished.

Copernicus's Work

A Landmark in Scientific History

By Professor H. Dingle (Imperial College)

At the junction of the fifteenth and sixteenth centuries two Churchmen from northern Europe went to Italy. The disgust aroused in one produced the Reformation: the stimulus received by the other gave the Renaissance its most pregnant symbol. Truly, we see what our eyes are fitted to perceive.

At the time of this visit, Nicolaus Copernicus was twenty-three years old. He was born, the youngest of four children, on February 19, 1473,

assumed the stars all to be at the same distance. In 1576 he revised the work of his father, Leonard Digges, the *Prognostication Everlasting*, for a new addition and added a supplement describing the Copernican system, entitled *A Perfit Description of the Caelestiall Orbes, according to the most aunciente doctrine of the Pythagoreans, latelye reuiued by Copernicus and by Geometricall Demonstrations approued.* He gave an English translation of the principal chapters of Book I of *De Revolutionibus*, with some paragraphs explaining his own ideas, of which the following is an extract:

> We may easily consider what litle portion of gods frame, our Elementare corruptible worlde is, but neuer sufficiently be able to admire the immensity of the Rest. Especially of that fixed Orbe garnished with lightes innumerable and reachinge vp in *Sphaericall* altitude without ende. Of whiche lightes Celestiall it is to bee thoughte that we onely behoulde sutch as are in the inferioure partes of the same Orbe, and as they are hygher, so seeme they of lesse and lesser quantity, euen tyll our sighte beinge not able farder to reache or conceyue, the greatest part rest by reason of their wonderfull distance inuisible vnto us.

Digges's diagram of the universe was similar to that of Copernicus, so far as the planets were concerned, but instead of placing the stars on a fixed outer sphere he showed them extending to the borders of his diagram, with the legend: 'This orbe of starres fixed infinitely vp extendeth hit self in altitude sphericallye, and therefore immouable; the pallace of foelicitye garnished with perpetuall shininge glorious lightes innumerable, farr excellinge our sonne both in quantitye and qualitye. . . .'

The *Perfit Description* went through at least seven editions between 1576 and 1606 and had great influence on contemporary thought in England. It enabled the average Englishman, who could not read Latin, to become familiar with the Copernican system and did much to bring about the earlier acceptance of the system in England than on the Continent. In 1584 Bruno published in England his speculations concerning the infinite universe in a small book, written in Italian, entitled *Dell infinito Universo et Mondi*, which may have been prompted by Digges's work. This book had no influence on English thought and Bruno's speculations were practically unknown in England until some years later, when his Latin work entitled *De Monade* became available. Bruno's writings, though they consisted mainly of metaphysical speculations, undoubtedly helped to carry the Copernican revolution a stage further by dethroning the sun and its planetary system from the central position in the universe.

But on the Continent the Copernican doctrine gained few adherents during the half century after the death of Copernicus, even though the Prutenic Tables had come into general use. Tycho Brahe, as we have seen, did not accept the Copernican system, yet the observations of this most assiduous and systematic observer of the heavens before the days of the telescope did much to help it forward. In 1572 a bright new star appeared, of which Tycho obtained a long series of observations. His discussion of these established that the star was not a comet, as many had thought, and that it was more distant than Saturn. His observations of the great comet of 1577 proved that the comet was far more distant than the moon and therefore not in the sphere of fire where, according to Aristotle, comets were situated. Thus the region beyond the moon was not, as Aristotle had supposed, eternal and unchanging and, moreover, the idea of solid spheres had to be finally abandoned. By giving so severe a blow to the Aristotelian theories, Tycho Brahe helped to remove one of the chief obstacles to the progress of the Copernican doctrines.

The first attempt at a physical explanation of the rotation of the earth was due to William Gilbert (1546–1603) who, in his *De Magnete*, published in 1600, ascribed it to the magnetic properties of the earth. Gilbert found that his terella or magnetized sphere rotated under the influence of a magnetic field. Though Gilbert's theory was not correct, it provided at the time a plausible explanation of the rotation and thereby removed an objection to the Copernican system. It was accepted by both Kepler and Galileo as a tentative hypothesis.

Before the time of Tycho Brahe, observations of the planets had been made mainly at opposition or at other interesting points of their orbits. Tycho had observed the sun, moon, and planets

at Thorn (Torun) on the Vistula, then and now a town of Poland. There has been much controversy concerning the nationality of his ancestors. In matters of blood and soil I have little interest and less knowledge, but two things may be noted. In the days when the Copernican astronomical system was an object of ridicule or anger, German writers spoke of its author as a Pole: only since he has been recognized as a great man have they claimed him as a German. Secondly, while Poland abounds in memorials of Copernicus, there is not, I understand, a single statue erected to his memory in Germany. Certainly there is no doubt which country deserves him.

At the age of ten, on the death of his father, Nicolaus came under the care of his maternal uncle, Lucas Watzelrode, who was soon to become Bishop of Ermland, one of the four provinces of Prussia at that time. He continued at school in Thorn until 1491 when, at the age of eighteen, he entered the University of Cracow, then in the forefront of university education in mathematics and astronomy. Here he became a pupil of Brudzewski, one of the leading astronomers of the time, and acquired some proficiency in astronomical observation. There can be little doubt that the seeds of his future career were sown at this time, but they did not germinate immediately. After three years at Cracow, Nicolaus returned to his uncle's home at Heilsberg and entered the service of the Church. Bishop Watzelrode failed in his first attempt to secure for him a canonry at Frauenburg, and he was accordingly allowed to resume his university studies. This time he went to Bologna and entered the school of law, where he obtained the degree of Master of Arts. During his stay he formed a close friendship with Novara, the Professor of Astronomy, with whom we are told he worked 'not so much a pupil as a helper and witness of the observations.' Novara, besides being an able and original astronomer, was a leader in the revival of Platonism which was just beginning to offer a serious challenge to the dominant Aristotelianism of the times. We can easily imagine that his influence might have had no small effect in creating in his young associate a critical attitude towards the accepted system of astronomy.

In 1500 Copernicus left Bologna for Rome, and remained there for twelve months, engaged in the private teaching of mathematics. It was then time to return home, where shortly after his departure for Bologna he had been elected a Canon of Frauenburg Cathedral. Almost immediately he sought and obtained further leave of absence to continue his legal studies, which he completed at Padua and Ferrara. At Padua also he studied medicine, and in 1506, after ten years of almost continuous study in Italy, he returned to Ermland to take up his clerical duties.

The remaining years of the life of Copernicus were outwardly full of arduous and varied activity. His official duties included not only those of a Churchman in the narrow sense, but also the medical care of a succession of moribund bishops and of the poor of the diocese, as well as much political work. This was no light matter in the circumstances of the time. Hostility between the Poles, the Prussians, and the Teutonic Knights led to his assuming charge of the military defence of his district and the responsibility for its interests at the subsequent Peace Conference. A resulting debasement of the coinage drew from him an analysis of the principles of currency which formed the basis of the new legislation by which the evil was remedied. Difficulties arising from the spread of Lutheran ideas added further burdens, and altogether the life of Copernicus was anything but the placid stream of contemplation which it is often supposed to have been.

Nevertheless, although this succession of public activities occupied the forefront of his life, in the background and much closer to his heart the development of his astronomical ideas pursued a steady and continuous course. There is no reason to suppose that his official duties were not conscientiously and efficiently performed—the evidence, in fact, is all to the contrary—but we may well believe that he gave himself to them with the same enthusiasm as that with which we lay aside our studies to be measured for a suit of clothes or to get our hair cut. His great work, *De Revolutionibus Orbium Coelestium*, published at the very end of his life, was com-

piled from notes on scraps of paper, margins of books, and even on walls, and the manuscript itself is covered with amendments, insertions, and deletions made at various times as his ideas developed and new observations were made. He tells us in the Preface, addressed to the Pope, Paul III, that he had worked at it not for nine years but well into the fourth period of that length, and when necessary (but only then, apparently; he was no great observer) he supplied missing information by observations of his own. These were made with an instrument of his own construction, and he seemed to have no illusions about their accuracy. 'If only I can be correct to ten minutes of arc,' he told his pupil, Rheticus, 'I shall be no less elated than Pythagoras is said to have been when he discovered the law of the right-angled triangle.'

Of his general character and temperament we know little save what can be inferred from the facts just outlined. No contemporary biography exists, and, apart from his published work, the only writings of his that remain are a few letters to his official superiors on matters of passing interest. From the point of view of those seeking to catch a glimpse of the man, the fact that requests for leave of absence are prominent in these letters is perhaps an example of the survival of the fittest. His portraits suggest a man of thought rather than of action, revealing strongly-marked features on which sits a gravity befitting the countenance of one who had stopped the sun and made the earth to turn. On his basic devotion to astronomy, the superficial layer of his casual interests shows considerable variety. He was proficient in languages, and published a translation from Greek into Latin of the poems of Theophylactus Simocatta. He was also an artist, of what skill we cannot judge, for the nearest existing approach to an example of his work is a copy by other hands of his self-portrait, which adorns the famous Cathedral clock-tower at Strasbourg.

Apart from a marked integrity and firmness of purpose, the one personal quality which I think we can deduce with some confidence is a certain humility or diffidence, which led him, on one hand, to shun publicity both for himself and for his work, and, on the other, to tend to depreciate his own worth in comparison with that of others. As a consequence, his work is an outstanding example of unaided individual thought; no interchange of opinion, no controversies disturbed or modified the gradual unfolding of his ideas. Not until four years before his death, when young Georg Jachim von Lauchen, better known as Rheticus, went on a pilgrimage to Frauenburg for a few weeks and remained for two years, had he even a pupil. From Rheticus we get what little direct evidence we have of his method of working. 'My teacher,' he writes, 'always has before his eyes the observations of all ages together with his own, assembled in order as in catalogues; then when some conclusion must be drawn or contribution made to the science and its principles, he proceeds from the earliest observations to his own, seeking the mutual relationship which harmonizes them all: the results thus obtained by correct inference under the guidance of Urania he then compares with the hypotheses of Ptolemy and the ancients; and having made a most careful examination of these hypotheses, he finds that astronomical proof requires their rejection; he assumes new hypotheses, not indeed without divine inspiration and the favour of the gods; by applying mathematics, he geometrically establishes the conclusions which can be drawn from them by correct inference; he then harmonizes the ancient observations and his own with the hypotheses which he has adopted; and after performing all these operations he finally writes down the laws of astronomy.'

Copernicus has often been criticized for placing undue trust in the observations of ancient astronomers—a trust which led him to accept non-existent inequalities as real. Certainly he over-estimated the accuracy of the records, but whether this justifies the criticism is perhaps open to question. When one's aim is to harmonize the observations of all ages, it is a poor beginning to explain away as inaccurate those which present difficulties. Copernicus certainly had no *blind* trust in the figures which he accepted. His *Letter Against Werner*—a criticism of a contemporary publication on the motion of the stellar sphere—is largely a discussion of the reasons why the observations of Ptolemy

and others were not lightly to be rejected, and we have seen that he was not insensible of the importance of knowing the degree of error to which his own observations were subject. 'For him,' says Rheticus, 'there is nothing better or more important than walking in the footsteps of Ptolemy and following, as Ptolemy did, the ancients and those who were much earlier than himself. However, when he became aware that the phenomena, which control the astronomer, and mathematics compelled him to make certain assumptions even against his wishes, it was enough, he thought, if he aimed his arrows by the same method to the same target as Ptolemy, even though he employed a bow and arrows of far different type of material from Ptolemy's—he is far from thinking that he should rashly depart, in a lust for novelty, from the sound opinions of the ancient philosophers, except for good reasons and when the facts themselves coerce him.' This was no bad testimonial, and though it refers specifically to the theories of Copernicus, it applies with no less force to his estimate of observations. It is entirely consistent with the humility, controlled by reason, which his general behaviour attests.

There is a world of difference, however, between such humility and timorousness. There is not a particle of evidence that he had any fear of making his views known, unless a shrinking from the ridicule of the unlearned may be so classed. The popular idea that he kept his thoughts secret from fear of persecution is entirely baseless. Certainly he did not publish his great work, *De Revolutionibus*, until the very end of his life, after overcoming great reluctance, but many years before he had circulated a summary account of his astronomical system in manuscript form among those qualified to judge of its worth, and through the medium of this *Commentariolus* his ideas were known wherever astronomy was studied. Rheticus went to him from Wittenberg 'to see if his achievement justified his reputation,' and ten years before his death a lecture on the Copernican system was delivered to the Pope and his Court by the Papal Secretary. Indeed, his reputation in astronomy was such that as early as 1514 he had received an invitation from the Lateran Council in Rome to assist in a reformation of the calendar, which, however, he refused on the ground that existing knowledge of the motions of the sun and moon was inadequate for the purpose. When the reformation was actually carried out towards the end of the century, it was based on the work of Copernicus.

What he did shrink from was the laughter of those whose sense of the absurdity of supposing that the obviously stationary earth could be moving was unbalanced by the astronomical knowledge which would justify the supposition. He had, in fact, in 1531 been satirized on the stage near Frauenburg, and there was no lack of comment such as that of Luther, who called him the 'new astrologer'—'the fool,' he said, 'would overturn the whole science of astronomy.' His sensitive nature was hurt by such misunderstanding, and in his dedicatory letter to the Pope, prefaced to *De Revolutionibus*, he expressly says that it was this consideration which had kept him from publishing his views before. 'When I considered with myself what an absurd fairy-tale people brought up in the opinion, sanctioned by many ages, that the earth is motionless in the midst of the heaven, as if it were the centre of it, would think it if I were to assert on the contrary that the earth is moved; I hesitated long whether I would give to the light my commentaries composed in proof of this motion, or whether it would indeed be more satisfactory to follow the example of the Pythagoreans and various others who were wont to pass down the mysteries of philosophy not by books, but from hand to hand only to their friends and relatives. . . . When therefore I had pondered these matters, the scorn which was to be feared on account of the novelty and the absurdity of the opinion impelled me for that reason to set aside entirely the book already drawn up.'

The path to publication was somewhat smoothed through the enthusiasm of Rheticus, who declared that Copernicus had made him see astronomy with both eyes as though a fog had been lifted, and that the new system had resurrected astronomy as Orpheus had brought back Eurydice from the underworld. He begged permission to publish the new doctrine, and this having been granted, the first printed account of the Copernican system appeared

in 1540 in the form of a letter from Rheticus to his old teacher, Schöner, bearing the title, *Narratio Prima de libris revolutionum*. It was based on Rheticus's study of the manuscript of *De Revolutionibus*, which he had not at that time completely mastered, and a second 'Narration' was promised. The reception accorded to the *Narratio Prima*, however, coupled with the earnest solicitations of his friends, at last overcame Copernicus's resistance, and he consented to the publication of his own work. The manuscript was entrusted to his friend, Tiedemann Giese, Bishop of Culm, who sent it to Rheticus. The great work was published in the spring of 1543, under the title, *De Revolutionibus Orbium Coelestium*, and a copy was brought to Copernicus in time to reach him on May 24th on his death-bed.

De Revolutionibus is not primarily a polemical work. It is a complete treatise on astronomy—a new *Almagest*—in which, however, the centre of the sun and not that of the earth is taken as the stationary point of the universe. The arguments for the change occupy a relatively small part of the book, the greater part being concerned with descriptions of the movements of the celestial circles, with mathematical theorems and tables and astronomical tables intended to supersede earlier ones. The great observational work of Tycho Brahe, however, was soon to make the tables obsolete, and the main feature of interest for future generations was the substitution of the heliostatic for the geostatic universe. To understand the significance of this it is necessary for us to look carefully into the state of astronomical thought in the days of Copernicus.

It is customary to think of pre-Copernican astronomy as a definite, universally-accepted system of thought, whose principles were summarized once for all in Ptolemy's *Almagest* and which became more and more complicated in application as observations accumulated. Unfortunately the position was not so simple as that. The astronomy of the time contained many elements, mixed in varying proportions, and some analysis is needed before we can begin to understand the intellectual world in which Copernicus lived. To begin with, astronomy was not the self-governing science that we know. Just as beyond the stellar spheres the blessed had their abode, so the realm of astronomical thought and practice was enclosed within the principles of general philosophy and physics, and was absolutely subject thereto. The dominant philosophy was certainly that of Aristotle, but there was a strong neo-Platonic element also, while the whole was, of course, profoundly modified by the requirements of the Sacred Scriptures and to a lesser extent by the interpretations thereof by the early Christian Fathers. Practical astronomy owed allegiance to Ptolemy, but the Ptolemaic system differed considerably from the Aristotelian, and astronomers felt the need, with various degrees of intensity, of establishing a reconciliation. A compromise solution might have been found by allowing the Ptolemaic system to be used for practical purposes while granting metaphysical 'truth' to Aristotle, and something along these lines, as we shall see, was done by many. Against it, however, was the fact that the chief 'practical purpose' of astronomical tables was the calculation of the dates of movable religious feasts, and these were obviously entitled to determination by absolute truth. Furthermore, without excessive complexity even the Ptolemaic system itself was unable to provide the degree of accuracy required, and by the time of Roger Bacon in the thirteenth century, the tables of the moon's phases were at least a week in error, so that the Church was degraded in the eyes of any common rustic who could distinguish the first quarter from the full moon. Such were a few of the conflicting factors of mediaeval astronomy.

Nevertheless, in the general confusion certain elements were more prominent than others, and despite innumerable differences in detail the broad outlines of a generally-acknowledged system of the universe can be discerned. We can best approach it by looking first at the Aristotelian and Ptolemaic systems in their original forms. And in describing the Aristotelian universe we must make a clear distinction between the underlying physical principles and the particular cosmic mechanism which exhibited the working of those principles, for in the centuries which followed, right up to the time of Galileo, the physical principles were

held to be absolutely inviolable, while the cosmic mechanism could, if necessary, be modified or even, in extremity, discarded altogether.

The principles of the Aristotelian physics which concern us are these. There was a fundamental distinction between sub-lunar and celestial matter. The former, consisting of the four elements, earth, water, air, fire, was subject to transformation, change, and corruption, while celestial matter was unchangeable and incorruptible. Motion was of two kinds—natural and violent—and bodies displaced by violence from their natural places in the universe sought those places again, so that violent motion was necessarily transient, while the natural motion of the imperturbable celestial spheres was eternal. This most perfect motion was uniform and circular, while the natural motion of displaced sub-lunar matter was rectilinear—either towards the centre of the universe (gravity) or away from it (levity). The universe was finite, so that rectilinear, unlike circular, motion necessarily terminated when the moving body had reached the centre or boundary of the universe.

These principles were exhibited in the operations of the universe, which was constructed in the following way. The earth, which was spherical, was stationary at the centre: this was clearly so, since sub-lunar matter, which necessarily moved towards or away from the centre of the universe, is observed to move towards or away from the centre of the earth. The stars were embedded in a sphere, concentric with the earth and, of course, of finite radius. The sun, moon, and planets had each a sphere of its own, on the equator of which it was fixed, and all the celestial spheres revolved round the earth in various periods. The spheres were linked together, and several intermediate ones were provided to allow such of the motion of one sphere as was necessary to be transmitted to another, for each sphere by itself could have only one simple circular motion. Though all the spheres were concentric with the earth, their axes were neither coincident nor necessarily constant in direction, and their revolution could be either from east to west or from west to east. In the whole system fifty-five spheres were found necessary to explain the observed motions.

In Aristotle's day (the fourth century B.C.) the recorded observations covered only a short period of time, and consequently the motions to be explained were relatively simple. This system of concentric spheres, which was originally designed by Eudoxus, accounted for them well enough. But the passage of time showed that its possibilities were too limited to cover the variations which gradually made themselves known, and new devices were necessary in order 'to save the phenomena.' Before leaving the Aristotelian system, however, we may note one characteristic which it transmitted to succeeding centuries at least up to the time of Copernicus and which we can recognize even in the Cartesian vortices. The motions which it sought to describe were not those of the heavenly bodies but those of the spheres which carried them; the bodies merely made visible the *resultant* motions, like straws showing the interaction of conflicting currents. When, later, circular orbits displaced the spheres as the centre of interest, it was still the motion of the circles that was the reality, not that of the planets, which gave a false appearance of irregularity to what was fundamentally a combination of uniform circular motions. The title of Copernicus's great work, *De Revolutionibus Orbium Coelestium*, does not mean *On the Revolution of the Heavenly Bodies*, but *On the Revolution of the Heavenly Spheres*, and although he uses the word *orbis* as meaning sometimes a sphere and sometimes a circle, it never stands for a star or a planet. (The last two words of the title were, in fact, written not by Copernicus but by Osiander, who saw the work through the press, but Copernicus uses them in the book itself, and his thought is in no way misrepresented by the addition.)

In the centuries which followed Aristotle not only did the accuracy of observation improve, but the gradually lengthening list of data revealed details in the planetary motions which no multiplication of concentric spheres could deal with. New devices were needed, and when, five hundred years later, the facts and principles of astronomy were summarized by Ptolemy in the famous *Almagest*, the system described bore little apparent resemblance to the Aristotelian universe. Let us glance briefly at the chief

phenomena to be explained before turning to the system itself.

The movements of the stars, which in Aristotle's day comprised only the uniform diurnal revolution, now included the precessional motion as well. The variations in distance and angular velocity of the sun were known with some accuracy, as were the more irregular ones of the moon, and with the moon there were variations of latitude and of longitude of perigee also to be explained. The five known planets showed similar 'inequalities,' as they were called, and in addition a recurring retrograde movement; and for each planet the various inequalities had peculiarities of their own. In particular, the 'inferior' planets, Venus and Mercury, were restricted within limited angular ranges from the sun, while the others could move all round the zodiac. These, in outline, were the facts to be accounted for.

In giving a rational description of them, Ptolemy acknowledged certain restrictions on his mathematical freedom. These were of two kinds: first, those imposed by metaphysical necessity—such as Aristotle's physical principles, including the distinction between terrestrial and celestial matter and terrestrial and celestial motion; and secondly, those which he adopted as postulates on grounds of experience or *a priori* probability. For the former naturally he offers no arguments—they are established in their own right—but the latter he enumerates at the beginning of his work, and he gives reasons for their adoption. They are that the whole universe is enclosed within a spherical heaven, which revolves as a sphere; that the earth also is spherical and is stationary at the centre of the heavenly sphere; and that the earth is practically a point compared with the universe.

The way is now clear for the construction of a system of uniform circular motions, the resultants of which must agree with the observed paths of the heavenly bodies; or, in other words, the movements of the heavenly bodies must be analysed into a series of combinations of uniform circular motions. Concentric spheres were unequal to the task, but two other devices had come into use since the time of Aristotle, and of these Ptolemy took full advantage. The first was the 'movable eccentric.' A planet could be regarded as moving in a circle whose ce was not the centre of the earth, and the ph mena required that the centre of this ci must always lie on the line joining the e and sun, so that it was itself movable. The c of a planet referred to the earth would clearly be very different from a circle, b would be compounded of uniform circ motions. The other device was that of cycles.' Here the planet was fixed on a revol circle, the centre of which was fixed on ano revolving circle, and so on, until at last a c was reached whose centre was stationary respect to the earth, though not necessarily i earth. This ultimate circle was called a *de* and the others *epicycles*.

Now these are not independent devices, as Ptolemy was well aware, for the sup planets any motion describable by a defe and epicycle was describable also by a mov eccentric. As we should now say, the analyses of the motion were geometrically e valent. The epicyclic analysis, however, the greater range of applicability and so though he did not discard eccentrics altoge Ptolemy usually adopted it. It can readil imagined that astronomy under these condi was the geometer's paradise. Notwithstan the severe limitation imposed by the restri to uniform circular motions, there remained ple scope for ingenuity. The circles could numerous as was necessary, their radii periods of revolution could have any va motion could be in either direction, and planes of the circles could have any inclina to one another. Indeed, Ptolemy took a fu liberty which, with Copernicus, we cannot regarding as cheating. He allowed an an motion to pass as uniform if it was so a *any* point inside the circle, not necessaril centre; in other words, he separated the ce of position and of uniform motion. The centre he called an *equant*. The device special interest to us now because in elli motion the equant is, by Kepler's second the focus of the ellipse. Nevertheless, ha referee, Aristotle, been on the field, we fea Ptolemy would have been penalized. Vie the problem as a whole, it is small wonde men of the genius of Apollonius, Hippar

and Ptolemy succeeded in constructing a system adequate to save the crudely measured phenomena for many centuries. It is unnecessary to go further into the details of the Ptolemaic system, but we may note as an obvious example that the retrograde motions of the planets revealed the existence of an epicyclic movement periodically carrying the bodies in the opposite direction to that in which the deferents moved. Between the Aristotelian and the Ptolemaic cosmologies there was thus little in common beyond the fundamental axioms and postulates. Ptolemy did not deny the spheres, but he ignored them, and by accepting eccentrics he went definitely beyond anything that Aristotle had contemplated. He was compelled to do so, however, if he was to save the phenomena, and in the centuries which followed, when the authority of Aristotle grew more and more absolute, and at the same time the phenomena grew more and more difficult to save even with the Ptolemaic liberties, the great problem was how to reconcile the two sets of ideas. One solution was to place the whole mechanism of deferent and epicycles for each body within the space between two spheres concentric with the earth, thus admitting the reality of the spheres without losing the advantages of the circles. A pair of spheres was conceived for each of the seven 'planets' (including sun and moon), the lower being the 'concave' and the upper the 'convex.' Owing to the great difference in the distances of perigee and apogee, the space between the spheres had to be granted considerable thickness, and in the absence of any means of measuring the distances, it was natural to assume that the concave of one body rested on the convex of that next beneath it. A typical system of this kind is portrayed in Apian's *Cosmographia*, published early in the sixteenth century. The original Ptolemaic system had, of course, become much complicated, and even the sphere of the fixed stars had become threefold. The eighth sphere, which contained the stars, was deprived of the diurnal motion, which was transferred to a tenth sphere—the *primum mobile*. The ninth sphere was responsible for the precessional motion, and to the eighth, the starry firmament itself, was assigned only the task of producing an illusory oscillation of the equinoxes known as *trepidation*, which burdened cosmological theory for many centuries until Tycho Brahe finally disposed of it late in the sixteenth century.

This ingenious compromise was certainly a solution of the problem, but it was not the only one. It appealed mainly to practical astronomers whose primary interest was in saving the phenomena, but philosophers, who valued above all things the Aristotelian principles, took another course. They insisted on a distinction between reality and mere calculating devices. The spheres were real, but inasmuch as they had failed to give an adequate account of the observations it was permitted to use mathematical artifices such as eccentrics and epicycles for purely practical purposes. This view was taken by, among others, men of such diverse types as Averroes and his great antagonist, Thomas Aquinas. It was a very convenient solution, for it not only avoided the immediate difficulties but gave absolute freedom to the mathematician to save the phenomena by any means he chose without having to consider the demands of reality. Indeed, the divorce of reality from mathematical description became so complete that some philosophers, though not Aquinas, never contemplated the possibility, or even desirability, of a reconciliation. Thus, the author of a cosmological system which attained wide popularity in mediaeval Spain and which claimed to explain the universe as it really was, expressly disclaimed any idea of testing his theory by observation, or of accounting at all for minor details of the motions.

Leaving such extreme views aside, however, we must admit a certain justification for the view that the Ptolemaic system was merely a calculating device. Ptolemy himself regarded it as such. His lunar theory, for example, required that the distance, and therefore the apparent diameter, of the moon should vary by nearly a hundred per cent during the course of the month, and this was certainly not observed. The result was that, as the centuries went by, astronomers, whether consciously or not, came to regard astronomy simply as pure geometry, and to isolate it not only from 'reality' but even from other fields of experience as well. This was carried to such an extent

that an astronomer, intent on solving the geometry of the heavens, could entirely forget that there were other phenomena to be saved, such as the brightness of the stars and planets, for example. Magnitude, originally a measure of brightness, had become a measure of apparent diameter. The stars were thought to appear as discs, and a definite angular diameter was assigned to each magnitude. Indeed, as late as the seventeenth century, even a modern like Galileo could describe Jupiter's satellites as 'brighter than the rest of the stars, equal to them in magnitude.' Copernicus, though postulating that the stars were, in effect, infinitely farther off than the planets, could yet believe that they shone by reflected sunlight. Tycho Brahe, after measuring the apparent diameters of the sun and moon, declared that the moon could not completely hide the sun, apparently forgetting the fact of total eclipses, and the same great observer gives us what must surely be the extreme example of the geometrization of astronomy in his deduction that Moses must have been a considerable astronomer because he called the moon the lesser light, although its apparent diameter was almost equal to that of the sun. Well might Rheticus call astronomy the 'Queen of mathematics'!

We shall return to this question of reality and artifice, but we leave it now to note one other element in the intellectual atmosphere in which Copernicus was born, before coming to his own work. The speculations of the early Greeks had been preserved through the dark ages by Arabian astronomers, from which the men of the Renaissance received it as a new revelation. The Arabs added little of value, but they saved it from oblivion. It is perhaps not surprising that European thinkers regarded their inheritance with a veneration approaching idolatry, and it became not only a habit but a consciously adopted practice to seek ancient authority for any ideas which they themselves might wish to consider. For example, in Bodin's *Drama of Universal Nature*, published so late as 1597, a dialogue is recorded between 'Theodore' and 'Mystagogue,' in which Theodore, confused by the variety of opinions on cosmical matters, is advised by Mystagogue to look to the sacred fountain of ancient writings for the resolution of his difficulties. 'The authority of such writers,' replies Theodore, 'has indeed so great weight with me that I place their statements far in advance of the arguments of all others. Nevertheless, if it can be done, I should wish to have this illustrated and confirmed by argument in order to satisfy those who believe nothing except on absolute proof.' This was a typical attitude. The desire for absolute proof had awakened, but it still lay prone in the bed of authority. No new idea dared proclaim itself without the credentials of ancient sanction.

I hope that this brief analysis of the structure of mediaeval thought has neither obscured the dominant ideas of the time, nor, on the other hand, over-simplified the complexities of a situation in which, as even the most superficial reading of contemporary literature will show, men were scarcely aware of the implications of their beliefs or of the inconsistencies involved in the flood of ideas which overwhelmed them. Both the old bottles of ancient learning and the new wine of re-awakened imagination were strange and charming, but they were ill fitted for one another. What men needed, but were not aware that they lacked, was a new outlook, a standpoint on attaining which the unperceived contradictions and complexities that confused their thinking would cease to operate, and a clear path to progress would become visible. It was this that Copernicus supplied. Looked at in the light of present knowledge, what he did seems small enough, particularly when contrasted with what he did not do. He had all the mediaeval reverence for authority; he believed in a finite universe bounded by a sphere of fixed stars; he accepted—nay, almost worshipped—the Aristotelian principles of motion; and in support of his own views he advanced the most metaphysical of arguments. What he did was simply to assign the diurnal motion to the rotation of the earth, and the annual motion to its revolution round the sun, and work out, by the old devices of eccentrics and epicycles, the astronomical consequences of these postulates. When we contemplate to-day the enormous results of this change we can scarcely avoid the thought that never has so mighty a mountain issued from so minute a mouse. We need to return to the sixteenth century to realize

the miracle needed for the creation of that mouse.

Before developing his system, Copernicus has to satisfy himself that he has authority for the liberty he is about to take; in an age of indulgences, he sought his from antiquity. 'Wherefore,' he says, 'I took upon myself the task of re-reading the books of all the philosophers which I could obtain. . . . And I found first that, according to Cicero, Nicetas had thought the earth was moved. Then later I discovered, according to Plutarch, that certain others had held the same opinion. . . . When from this, therefore, I had conceived its possibility I myself also began to meditate upon the mobility of the earth.' The result of his meditations convinced him that this supposition converted the heterogeneous mass of celestial motions into a single organized system, so that 'in no single part could one thing be altered without confusion among the other parts and in all the universe.' This consideration appears to have convinced him that the hypothesis was justified, but there were grave objections to be answered. The immobility of the earth, it will be remembered, was one of the postulates of Ptolemy, supported by arguments from experience, and these arguments had to be met—and met, moreover, without violating the Aristotelian principles of motion. Copernicus deals with them in the following way.

Consider first the earth's rotation. It is clear that if the earth rotates, a falling body no longer moves rectilinearly, for to its apparent rectilinear motion must be added the circular motion of the earth. Copernicus counters this with the claim that although, as Aristotle had said, there were natural and violent motions, all natural motions were circular. Even a rectilinear motion, as Arab astronomers had shown and he himself had proved, could be represented by a combination of circular motions, and so long as a terrestrial body remained in its natural place it shared the circular motion of the earth. When it was displaced, however, its motion was no longer natural but violent; hence its behaviour was not inconsistent with Aristotelian physics.

A second argument was that if the earth rotated there would be a mighty east wind, clouds and objects thrown into the air would be left behind, birds would not be able to return to their nests, and so on. In reply to this Copernicus maintained that the air must share the earth's rotation, and so carry along everything floating in it. A third argument, that rotation would result in the scattering and disruption of the earth's surface by what we should now call centrifugal force, he was not able properly to answer; its refutation awaited the mechanics of Galileo. He could reply, however, that such an effect would have far more serious consequences for the stellar sphere if that moved, so that his system at least made the best of a bad job and was therefore to be preferred.

The annual motion offered less difficulty in principle, though in practice it took much longer to win general assent. Ptolemy had agreed that the earth must be at the centre of the universe chiefly for two reasons. First, bodies which must move towards the centre of the universe move towards the centre of the earth. Secondly, the celestial sphere appears equally far off in all directions all through the year; or, in other words, the stars show no parallaxes. On the first point, Copernicus conjectures that gravity is a local phenomenon, representing the tendency to consolidation of any astronomical body; thus, objects on the surface of the sun would similarly move towards the centre of the sun, and not necessarily towards the centre of the universe. This was a remarkable anticipation of universal gravitation, but it was, of course, a mere guess for which no evidence was offered. The absence of observable stellar parallaxes Copernicus attributes to the great distance of the stellar sphere compared with the dimensions of the earth's orbit, but here again he could offer no independent evidence to support his contention.

Having thus at least shown that there was no fatal objection to the earth's mobility, Copernicus proceeds to develop the details of his system, of which we need only glance at a few typical features. The diurnal motion having been transferred to the earth, the stellar sphere was reduced to rest; its radius, though unknowably great, was finite, and its original unity was restored by giving to the earth also the precessional and trepidational movements. The

earth thus had three motions assigned to it—a great stumbling-block to many who might have been prepared to grant it one. The first motion —the daily rotation—accounted for the rising and setting of the heavenly bodies, and the second, an eccentric circle round the sun, for the passage of the sun along the ecliptic and the retrograde motions of the planets. The third motion was necessary in the first instance because, since, as we have seen, celestial revolutions were always conceived as belonging to the *orbes* in which the heavenly bodies were fixed, the celestial pole would move in an annual circle unless a counteracting movement were provided. Other birds were killed with the same stone by making this movement such as to account also for precession and its illusory variations.

The sun, of course, like the sphere of stars, was now at rest, and for the moon and planets Copernicus provided eccentrics, deferents, and epicycles of the traditional kinds. His system had, however, a great advantage over rivals in that the first inequalities—the retrograde motions—of all the planets were now accounted for as mere appearances due to a single movement of the earth—the parallactic motion, in fact, which the stars were too far off to show. As a consequence he was able to reduce the number of circles required for the whole universe from about eighty to thirty-four. Moreover, he had, for the first time, a definite criterion for assigning relative distances to the planets, for the amplitude of the retrograde motion would clearly depend on the distance of the body showing it. It was now immediately obvious also why the superior planets should be in perigee when in opposition, and why the periods of the epicycles which had previously accounted for the retrograde motions should have been so curiously related to the period of the sun. His treatment of the moon is interesting, for it gives us a good example of his mathematical skill. His problem here was directly comparable with that of Ptolemy, for both held that the moon revolved round the earth. Copernicus, however, was at a disadvantage, for his conscience would not allow him an equant; yet he succeeded in representing the moon's motion with a variation in apparent diameter indistinguishable with his instrument from the actual one, in contrast to the inadmissibly great variations of Ptolemy. As an appropriate reward for his faithful observance of the rule of uniform motion he was elated to find that in his system all circles moved in the same direction.

Such was the system to the construction of which Copernicus devoted the greater part of his life. Notwithstanding the enthusiasm of his friends and disciples, what he feared was only too well realized. For many years, except among the few who were both willing and able to appraise its worth, the strange new doctrine was an object of contemptuous amusement scarcely deserving the compliment of disproof. Galileo tells us that, half a century after the death of Copernicus, he himself thought the whole idea a foolish whim, until he noticed that the few who praised it well understood Ptolemy and could give reasons for their belief, whereas the many who scoffed knew nothing of the system except that it was clearly absurd. It is pleasing to note that England was somewhat in advance of the Continent in this matter, and in 1619, for example, the Statutes of the new Savilian Professorship of Astronomy at Oxford required that the Professor, in addition to lecturing on the *Almagest* of Ptolemy, should also present in their proper places the newer theories of Copernicus and other recent astronomers. I have not inquired whether the Statutes are faithfully observed by the present Savilian Professor.

We must, however, avoid the common illusion that there was at first any appreciable opposition to Copernicanism on religious grounds. So far as any notice was taken of it at all, the initial reaction was on the whole favourable in Roman Catholic circles and contemptuously antagonistic among the reformers, but no attempt at suppression or persecution was made for many years. And, indeed, there was nothing in the new astronomy itself to call for such action; the danger lay in its potentialities, and these were not at first realized. Whitehead has said that Pope Urban, when faced with the *Dialogues* of Galileo, even if his infallibility tottered, was assisted by the gift of prophecy and smelt Voltaire. Pope Paul was less richly endowed, and

failed to smell Bruno. Such religious objection as was made to the hypothesis was based on its supposed incompatibility with the sacred Scriptures, but these were broad enough to imply, as well as deny, the earth's mobility, and no one foresaw the wider issues of the new idea. The relegation of man to a subordinate place in the universe was not an early menace. There had never been any lack of appreciation of the physical insignificance of man compared with the material universe. 'When I consider the heavens, the work of thy fingers, the moon and the stars, which thou hast ordained; what is man?' Moreover, the change introduced by Copernicus was not the substitution of a heliocentric for a geocentric, but of a heliostatic for a geostatic view. In the successive forms of the Ptolemaic system the earth had never been at the centre of either position or uniform motion of any celestial body except the sphere of the fixed stars, and in the Copernican system the sun was eccentric to the planetary orbits. The significance of Copernicus's work was that it changed the *state of motion*, not the *position*, of the earth, and that was not in itself an abasement, but rather an exaltation. It was the superior matter to which belonged the perfect circular motion, and to Aristotle it was motion and not rest that was a sign of perfection, and the swiftest motion was the most divine. There is no reason to think that the mobility of the earth was in itself objectionable on religious grounds; it was rejected not because it was impious but because it was absurd.

It was when new philosophies arose which challenged the existing philosophy of Christianity that the trouble began. It was seen that the apparently harmless mathematical *capriccio* which Copernicus had perpetuated was a potential source of the gravest heresies. In particular, it was but a step from the new astronomical ideas to the notion of an infinite universe. Copernicus had not taken that step, but he had removed the insuperable obstacle to it—namely, that if the universe were infinite the stars would have to travel with infinite velocity to complete their diurnal course. By transferring the diurnal motion to the earth Copernicus had opened the door to infinite space. Now an infinite material universe, with no abode of the blessed beyond the outermost sphere, could not be tolerated. The Church had overruled even Aristotle with respect to infinite time; it needed its creation and judgement day. It was not prepared, after rejecting eternity, to accept infinity. Consequently, when the removal of Bruno was followed by the discoveries and unanswerable polemics of Galileo, the evil had to be destroyed at its source. In 1616, seventy-three years after its publication, *De Revolutionibus* was placed on the Index. It remained there until 1835.

What did Copernicus himself think of the philosophical significance of his work? Before he committed himself to publication he entered into correspondence with his friend and disciple. Andreas Osiander, a Lutheran divine who later assisted in the passage of the book through the press. The letters of Copernicus are lost, but it is on record that Osiander wrote in the following terms: 'For my part, I have always felt about hypotheses that they are not articles of faith, but bases of calculation, so that, even if they be false, it matters not so long as they exactly represent the phenomena of the motions. . . . It would therefore seem an excellent thing for you to touch a little on this point in the Preface. For you would thus render more complacent the Aristotelians and theologians whose contradiction you fear.' When the book appeared it did, in fact, contain a Preface, in addition to that addressed to the Pope, expressing precisely this view. For some time it was believed that this Preface, though unsigned, was the work of Copernicus himself, until Kepler revealed the whole story, from which it appeared that it was written and inserted by Osiander without Copernicus's knowledge.

Two conclusions have geen generally drawn from these facts, for neither of which there is strong evidence and which, I think, are both unlikely. It is assumed, first, that Copernicus sought Osiander's opinion because he feared opposition to his ideas on religious grounds; and secondly, that he himself did not regard his system merely as a mathematical description but as a true account of the universe as it really was.

On the first point we have Copernicus's clearly expressed statement that what made him

hesitate to publish his views was his sense of their seeming absurdity, not at all their heretical character. He had been urged to publish by many influential Churchmen, including Schönberg, the Cardinal Bishop of Capua, and Tiedemann Giese, Bishop of Culm, and the Pope himself was prepared to accept dedication of the book. Is it likely, in view of this, that Copernicus would have attached any weight to the fears of an obscure Lutheran with whose religious doctrines he is known to have had little sympathy? It is probable enough that Osiander, to whom the strongly expressed opposition of Luther and Melanchthon must have been a matter of great moment, would have been anxious to preserve his adherence to the new astronomy from taint of infidelity, and it may well be supposed that he had read into a casual inquiry of Copernicus an anxiety whose origin was in himself. But there seems no ground at all for believing that Osiander's fears reflected those of Copernicus.

The second point is of more importance. Did Copernicus regard his system as a real account of the universe or merely as a calculating device? I do not think we have sufficient data to answer this question definitively, even if we could fully understand what the alternatives meant to him. Certainly, if the question had been: 'Is the Ptolemaic doctrine of a stationary earth the real truth, and the hypothesis that the earth moves merely a convenient artifice for solving astronomical problems?' (the question, it may be noted, to which Galileo was later compelled to give a particular answer), Copernicus would have answered emphatically in the negative. He would not have acknowledged his system inferior to Ptolemy's in any respect. We know also that he sometimes spoke of the 'real' movement of the earth, according to his system, in contrast to certain 'apparent' movements of the heavenly bodies arising thereform. But to the larger question, 'Are all geometrical descriptions of the universe valid only for purposes of calculation, the real truth of the matter being inaccessible by geometrical analysis?' we have, so far as I can gather, no evidence as to what answer he would have given. He makes no definite statement on the point, and the fact that he describes his system as a 'hypothesis' tells us nothing since we cannot be sure what he means by that word. The evidence that he might have regarded his system as falling short of reality seems to me at least as strong as that to the contrary. He cannot, for instance, have been quite insensible of the difficulty which was to be emphasized so strongly by Tycho Brahe, that the apparent diameters of the stars, coupled with the absence of observable parallaxes, implied incredibly great dimensions of the stars themselves. Nor could he have been unaware that he had not answered the mechanical objections to the earth's motion—in particular that relating to the effects of centrifugal force. He had compared his system favourably with Ptolemy's in this respect, but Ptolemy's system made no claim to reality, and he for whom there was nothing better or more important than walking in the footsteps of Ptolemy would scarcely have leaped so far ahead without giving some indication that he was doing so. The doctrine of the purely practical status of astronomy was, as we have seen, widely accepted among the philosophers of the time, and Copernicus would have shown no inconsistency or peculiarity if, while believing strongly in the superiority of his system to all others, he had yet held that the best in this kind were but shadows.

The point at issue is not yet entirely a matter of historical interest, though I think that by the time the next centenary of *De Revolutionibus* comes to be celebrated it will be difficult, if not impossible, to understand what all the controversy was about. We may leave aside the question of revelation, which concerns the method of arriving at truth rather than what truth may be. The question is then reduced to this: Is a scientific explanation of phenomena the real truth? If two different mathematical descriptions of a physical situation are equally consistent with the facts, which is the true one? It is only in this century that a definite, general answer has been given, and it is simply that the sole aim and achievement of science is to save the phenomena—that is, to find a rational connection between the observations—and provided this is done, the word 'real' or 'true' is a meaningless label. Of the two descriptions assumed we may adopt whichever

we please, for, apart from convenience which is usually equivocal, no physical criterion exists by which the status of one can be given superiority to that of the other.

At the time of Copernicus this answer had not been formulated, though in particularly obvious cases its validity was generally acknowledged. Thus, the complete equivalence in certain problems of the movable eccentric and the system of deferent and epicycle was accepted, and no one thought of describing one device as real and the other as fictitious. Perhaps the equivalence of rectilinear motion and a particular combination of circular motions, to which I have already referred, was accepted with less readiness, for since motion in a circle was accorded the highest perfection, it would seem to have been a significant question whether a particular body was moving in a straight line or in a circle rolling on another circle. To-day we have no difficulty in recognizing the purely formal character of this distinction, but it is not long since the question, 'Is a body at rest or moving with uniform velocity and experiencing a corresponding "contraction"?' was thought to be a sensible one; and even now we still perplex ourselves with such problems as, 'Is it a change in the velocity or in the frequency of light that is really indicated by the nebular red-shift?' It will take a few generations yet before we lose the habit of thinking that names have a physical significance.

Whatever may have been Copernicus's view of his work, however, we, who look back at it across four hundred years of astronomical progress, see it as one of the greatest landmarks in scientific history. Without it the work of Kepler and Newton, and hence the whole of modern dynamical astronomy, would have been impossible. It did not mark the beginning of a new era, but the logical closure of the old. Mediaeval astronomy was like a restless ghost.

> Wandering between two worlds, one dead,
> The other powerless to be born.

Copernicus made the birth of the new world possible. 'Through the Middle Ages,' wrote John Addington Symonds in his well-known *Encyclopaedia Britannica* article on the Renaissance, 'there were by no means lacking elements of native vigour ready to burst forth. What was wanting was not vitality and licence, not audacity of speculation, not lawless instinct or rebellious impulse. It was rather the right touch on life . . . the right way of approaching the materials of philosophy . . . that failed. . . . The path from darkness to light was lost.' It was the right touch that Copernicus supplied. He was no audacious speculator; he accepted implicitly and rigorously the Aristotelian metaphysics; but within the framework of that system he found the right way of approaching the materials of astronomy, and made visible, though he did not tread, the path from darkness to light. The elements of the astronomical universe could not break the shell of Aristotelian physics until they were formed into a living, organic system, and it was Copernicus who organized them. Then, and only then, could modern science be born.

It is always harder to acknowledge the stature of those who make great achievements possible than to pay homage to the authors of those achievements. The foundation of scientific method by Galileo and Newton has, by the very magnitude of its consequences, cast a shadow of quaintness and immaturity on the thought of the preceding time. How is it, we ask, that if Copernicus was really an original thinker he could accept so implicitly the metaphysical principles which to us seem so baseless? We cannot, perhaps, give a complete answer to this question, but we can say with certainty that if consistency is to be a requirement of greatness, the first great man has yet to be born. Why is it that many, who to-day sincerely believe that three distinct Persons are yet one God, complain that physics is talking nonsense when it suggests that a wave and a particle are yet one electron? Our imperfections are, on the whole, not those of the sixteenth century, but they will doubtless appear equally childish four centuries hence. If Copernicus did not free himself altogether from illusions, he has at least one outstanding distinction: in an age when even the greatest could not escape from astrological speculations, he alone seems to have transcended them altogether. And are we ourselves, after all, so free from taint of metaphysics as we like to believe? The fundamental truth

of science, that no general principles shall direc
our thinking that are neither logical necessitie
nor inductions from experience in the New
tonian sense, is an inheritance demanding per
petual vigilance for its preservation. Meta
physical principles, expressed or implicit, hav
perverted our thought from the earliest time
and even to-day our noblest minds have no
escaped their enticements. 'Celestial motion
are circular'; 'Nature does nothing by leaps
'At every instant there is a uniquely specifiab
configuration of the universe'; 'No physical co
cept is permissible which cannot be embodi
in a mechanical model'; 'Every activity gene
ates its contrary, by union with which
advances to a higher activity'; 'The universe
homogeneous' — such phantoms, guarante
neither by reason nor by experience, but on
by seductive appearance, are no prerogative
the sixteenth century. If Ulysses had been
cosmologist, it would not have been difficult
guess what song the Sirens sang.

To form a just estimate of the greatness
Copernicus we must turn to his contemporar
or to the generations which immediately follo
ed, for whether or not greatness is an absol
quality, it can be determined only in relati
to its immediate surroundings. After the co
demnation of Galileo the Inquisition felt
need of defending its action, and the Jes
astronomer, Riccioli, was commissioned to wr
an account of the matter with this end in vi
In order to show that the balance of opin
was against the earth's mobility, Riccioli g
the following lists of the astronomers who t
the two views, and he claimed, on the grou
of numbers, that the noes had it.

For the Earth's Mobility.	*Against the Earth'* *Mobility.*
Copernicus.	Aristotle.
Rheticus.	Ptolemy.
Maestlin.	Theon the Alexandr
Kepler.	Regiomontanus.
Rothman.	Alfraganus.
Galileo	Macrobius.
Gilbert (diurnal motion).	Cleomedes.
Foscarini.	Petrus Aliacensis.
Didacus Stunica.	George Buchanan.
Ismael Bullialdus.	Maurolycus.
Jacob Lansberg.	Clavius.

Peter Herigonus.
Gassendi—'but submits his intellect captive to the Church decrees.'
Descartes 'inclines to this belief.'
A. L. Politianus.
Bruno.
Barocius.
Michael Neander.
Telesius.
Martinengus.
Justus-Lipsius.
Scheiner.
Tycho.
Tasso.
Scipio Claramontius.
Michael Incofer.
Fromundus.
Jacob Ascarisius.
Julius Caesar La Galla.
Tanner.
Bartholomaeus Amicus.
Antonio Rocce.
Marius Mersennius.
Polacco.
Kircher.
Spinella.
Pineda.
Lorinis
Mastrius.
Bellutris.
Poncius.
Delphinus.
Elephantutius.

It was well that he emphasized quantity rather than quality, for if the latter be considered, no more striking witness against his contention can well be imagined: on one side the meaner beauties of the night; on the other the moon and sun. How many men of the dimensions of Elephantutius would be required to outweigh one Galileo? Moreover, even the evidence of numbers itself is not properly represented here. Those whose names are underlined (they were not so distinguished by Riccioli) should have been omitted, or else pre-Copernican believers in the earth's mobility, such as Pythagoras, Aristarchus, Nicholas of Cusa, should have been included on the other side. And when, neglecting the host of the illustrious obscure, we turn to the great men themselves, what do they say? Tycho, the outstanding dissenter from the Copernican doctrine, whose system was nevertheless mathematically equivalent to that of Copernicus, wrote: 'The earth has not produced his equal for many centuries. . . . He has done what it has not been given to any mortal to accomplish since the beginning of the world. Who is his

science. In Japan they encountered hostility from the authorities, and only certain private individuals remote from the influence of the Government could make the earliest contacts with the 'southern barbarians.' The century of Christianity from 1545 to 1630 failed to establish permanently the wealth of ideas from the West. In 1616 the Shogun Ieyasu abolished the right of missionaries to enter the country and to teach the principles of Christianity, and consequently the spreading of scientific ideas from the mysterious Western world passed out of the hands of the Portuguese Jesuits to the Dutch merchants, the only people allowed to trade, under very difficult conditions, with a nation that had adopted a closed-country policy. A small island, Deshima, lying at the entrance to the Port of Nagasaki, became the trading centre and the only entry for European science.

After the prohibition of Christian propaganda there was an increase among all classes of interest in the Western science known to the Dutch traders, whereas in China only the upper classes were interested in the 'mysteries of Western civilization.' In the seventeenth century the Dutch introduced to Nagasaki books on astronomy, medicine, mathematics, and the military arts, and these books were not only bought and highly appreciated, but were also translated into Japanese and eagerly studied.

Captain Boxer[1] notes that the Chinese had at their disposal the flower of European intellect, men familiar not only with Western science, but also with the Chinese language, able therefore to disseminate knowledge with the perfection of scholarship. In Japan, however, more was demanded of the Dutch traders than they were competent to give. The Japanese had first to overcome the difficulties of the Dutch language, which they did only by great efforts.

* * *

There is not the same uneasiness about celestial investigation in the developing civilization of the Far East as is shown in our Western world. European civilization, with its Christian background, assumes an ethical conception of heaven: it makes a spiritual symbol out of the material sky. Chinese civilization, however, has a materialistic and speculative approach to the sky, regarding it as something which differs from earth, and accepting among its components the stars, which influence the affairs of earth in that they are harmonious or inharmonious. They recognize that man must find a formula of individual and social behaviour which is in harmony with heaven. But this question is not sufficiently important for the relationship between material sky and abstract heaven to create social upheaval. It would be interesting to investigate from this angle the influence of European astronomy on the formation of the Eastern outlook: but this is rather outside our scope, which is limited to the influence of the Copernican discoveries in the West on the study of astronomy in the East. We must chiefly consider Copernican astronomy: the same breakaway occurred in the Far East as was witnessed in Europe when Copernicus 'stopped the sun and moved the earth.' The Jesuits taught Ptolemaic astronomy from the beginning, that is, the days of Fr. Matteo Ricci. They changed over to the Copernican system in the seventeenth century.

Papers on astronomy written in Dutch and containing some news of the Copernican theory were brought into Japan by the Dutch traders, for the most part Protestant, who under a special edict were permitted to trade with the country. After 1610 the Portuguese missionaries had to leave Japan. Nevertheless, as late as the second half of the seventeenth century the teaching of the Portuguese Jesuits was penetrating Japan, still showing the influence of the Ptolemaic theories.[2]

Seventeenth-century Japan had behind her two hundred and fifty years of cruel oppression. Scholars suffered astonishing persecution under the feudal regime of the samurai. With courage and heroism they endeavoured to gather together books and astronomical instruments, maps and drawings, from the Dutch traders. In this way these merchants fulfilled a great mission for civilization in Japan, as important as the sacrifices of the Catholic missionaries in China.

A period of great development in mathematical knowledge for feudal Japan began in the first half of the seventeenth century. This preceded

[1] *Jap Company in Japan, 1600–1817*, pp. xiv-xv, Hague, 1936. [2] See *Wakan-sansai-zue*, part 'Tien,' Edo, 1706.

COPERNICUS 1473–1543*

By A. Vibert Douglas
Kingston Centre, R.A.S.C.

The life span of Copernicus covers a period in history filled with movement in many spheres of human endeavour. It was an age of intolerance and reaction on the one hand and of high adventure and daring on the other.

These were the years when Michelangelo was at work in the realm of art; when Martin Luther was breaking with traditional theology and fighting for freedom of thought and conscience in the realm of religion; when Paracelsus was vitalizing mediæval medicine and Vesalius was making of anatomy a modern science; when the Moors with their rich Arabic learning were being pushed out of Spain, while Italy, the main centre of European scholarship, was gradually awakening from an intermittent sleep of twelve centuries. In these years when Christopher Columbus was sailing uncharted seas to discover the islands of a new continent, Copernicus was turning his back upon the ancient cosmologies to give the world the heliocentric model of the Universe.

In the thirteenth century the Teutonic Knights had founded the town of Torun or Thorn on the broad, navigable Vistula. This became an important trading port of the Hanseatic League. From Cracow, the chief town of Poland, a prosperous merchant named Niklas Koppernigk moved to Torun, married the daughter of a Polish-German merchant of that town, and on Feb. 19, 1473 their fourth child, Niklas, was born. This boy grew up to become one of the makers of modern thought. When he reached the stage of productive scholarship, he followed the custom of the scholars of his day by publishing his works in Latin, and like so many of them he Latinized his name as author. Thus we know him not as Niklas Koppernigk, but as Copernicus.

*This article is based on a paper which appeared in the Queen's Quarterly, vol. L, no. 2, 1943 commemorating the 400th anniversary of his death.

The education of Copernicus was long and varied. From the school of Torun he went to the University of Cracow in 1491. Here he found a strong school of mathematics and astronomy and no doubt studied the only two cosmologies that had survived the centuries since the rich speculative and mathematical period of Greek science. The simple Aristotelian system was based upon the geocentric universe of Pythagoras. The more complicated Ptolemaic system was built upon the ingenious work of the great Greek geometers who used circles and epicycles to reproduce the apparent motions of sun, moon and planets. While the Earth was not placed at the centre of these circles, it was still within the circles of all the heavenly bodies, and thus sun, moon, planets and stars moved around it.

In 1496 Copernicus went to Bologna where he worked at the school of law for four years. Here too he found astronomical interests in the observations and theories of the professor of astronomy, a brilliant man with an independent, critical mind, a leader in the current revival of Platonism. To the left of the great bronze doors to the Assembly Hall is a plaque to Dante Alegheri, Scholar in Bologna, 1287, and on the right a plaque to "Copernicus of Poland glorious son of this institution", ~~erected in 1836~~.

Copernicus next went to Rome where he took private pupils in Mathematics, but a year later he resumed his legal studies at Padua. Here he also studied Greek and began his wide reading in Greek science which led to his discovering for himself the half-forgotten speculations of Heraclides, Ecphantus and Hicetas on the axial rotation of the earth, and the heliocentric system of Aristarchus of Samos. This last was indeed a forerunner of the great scientific life-work of Copernicus, but it had been backed up in the third century B.C. by not one logical argument based upon astronomical observation which could overthrow the amazing partial success of the elaborate systems built upon the epicycles of Eudoxus.

Leaving Padua, Copernicus went to Ferrara where in 1503 he obtained his doctorate in Canon Law. He then returned to Padua and applied himself to the study of medicine until the end of the year 1505. In the meantime his uncle, the Bishop of Varmia or Ermland, had succeeded in getting this scholarly nephew elected to a canonry at Frauenburg Cathedral. This appointment imposed no obligation to advance in ecclesiastical position beyond the first vows necessary for admission, and beyond this first stage Copernicus never went although he remained a member of the Chapter until his death thirty-seven years later.

For six years after taking up his residence as a Canon of Frauenburg, Copernicus served as medical attendant upon his uncle at the Bishop's palace which was the castle of Heilsburg. Here he was able to devote time to astronomical pursuits as well as to exercise the art of healing amongst the

Introduction

Copernicus is an enigma. He has been called the timid canon by Koestler. In an age of speculation he was venturesome in his thinking and he was also ultra-conservative. His great book De Revolutionibus Orbis coelestium is full of inaccuracies, inconsistencies and forced arguments and yet it made history.

Who and what was this man?

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April 6, 1973.

ecclesiastics and the poor of the diocese, on one occasion being summoned to Königsberg by the Duke of Prussia to attend a high official in his grave illness. At this time, too, he became experienced in political and administrative work. Varmia was trying to maintain a measure of independence with the powerful Teutonic Knights on three sides and Poland on the fourth. The Bishop had many problems arising from a population partly German, partly Polish, within his own principality; and also in neighbouring West Prussia where he was asked to mediate in the racial dispute. Copernicus carried out diplomatic missions for his uncle and after the Bishop's death he was entrusted with the temporal and spiritual administration of the remoter parts of the diocese. Later when war developed between Poland and East Prussia involving the would-be neutral territory of Varmia with bombardment, raids and pillage, Copernicus proved himself the strong man with high qualities of leadership and practical foresight. At the peace conference following the 1521 armistice it was Copernicus who presented the claims of Varmia for war damage.

The coinage of the Prussian states, already debased before the war, now presented very serious problems, both internally and in neighbouring states. Copernicus placed before the local diet a scheme for monetary reform, and in a report published first in German and later in Latin he set forth his plan for recoinage and enunciated what later became known as Gresham's Law.

During these years with their multifarious duties, Copernicus had laid the foundations of his planetary theory and written the first draft of *De Revolutionibus Orbium Coelestium*. He had used the primitive instruments then in vogue to make observations upon some of which the arguments in favour of his theory were based. He had published accounts of the construction of a meridian quadrant and of a Ptolemaic astrolabe. One work only of a purely literary character came from his pen, his Latin translation of the Greek Epistles of the poet Simocatta, published in Cracow in 1509 when he was in that city on diplomatic business.

For six months in 1523 Copernicus was the Administrator-General of the diocese. Then a new Bishop was appointed and thereafter Copernicus was less burdened with the affairs of the world about him and could give closer attention to the astronomical problems which had absorbed his thoughts for so many years. Peace had come to the land with the triumph of Poland over the Teutonic Knights; but there could be no peace in the minds of thinking men and seekers after truth. Intolerance was growing and was soon to reach new peaks of viciousness in defence of orthodoxy against the teachings of Luther and against any scholarly work that cast a shadow of doubt upon that amazing synthesis, by St. Thomas Aquinas and other Church Fathers, of Judaic thought, Christian doctrine and Greek philosophy and science.

In the years 1523-32 Copernicus revised the manuscript of his great book, but apparently he made no attempt to publish it. It was known to exist, however, but only a very few scholars had the vision and the courage to be openly interested. In 1536 Cardinal Schönberg of Capua wrote to Copernicus as follows:

> Having constantly heard of your talent, I have begun to honour you more fully, and to congratulate our countrymen amongst whom you have flourished with so great renown. For I had perceived that you were not only well versed in the works of the old mathematicians, but also had propounded a new theory of the universe. By it you teach that the earth moves, that the sun is at the bottom of the universe, and indeed holds the middle place. That the eighth heaven remains immovable and eternally fixed. That the moon, with the elements included in her sphere, placed between the heaven of Mars and Venus, revolves in a yearly course round the sun. And that you have written commentaries on this whole theory of astronomy, and have reduced into tables the motions of the planets, computed from calculations, to the great admiration of everyone. Wherefore I beseech you, most learned man, ~~if I am not troubling you,~~ to impart this your discovery to the learned, and also to send to me in the first place your lucubrations concerning the sphere of the universe, with the tables, and anything else you have pertaining to the same matter. And if you will gratify me in this, you will find that you have to do with a man careful of your name, and one anxious to do justice to such great talent. Farewell. At Rome, Calends of November, 1536.

In 1539 a youthful German professor of mathematics came to visit ~~Copernicus at Frauenburg~~. His name was Joachim von Lauchen, alias Rheticus, and as he was one of Melanchthon's men from the Protestant University at Wittenberg, not only was he running a risk himself remaining in an atmosphere of latent hostility and suspicion, but his presence inevitably focused suspicion on Copernicus. Nevertheless the Canon of Frauenburg welcomed Rheticus, expounded his cosmology, ~~encouraged~~ him to summarize the manuscript and to publish the summary in Danzig in 1540. On his next visit Rheticus summarized the chapters dealing with plane and spherical trigonometry which Copernicus had brought together and generalized from the works of Ptolemy, and these he published at Wittenberg in 1542.

Copernicus had obviously withheld his book lest its publication should lead to open opposition to his investigations, but he now wrote to Osiander, a Lutheran theologian and an able mathematician, asking him whether in his judgement the work would give offence. Osiander's reply dated April 20, 1541, is in part thus "... I have always felt about hypotheses that they are not articles of faith, but bases of calculations ..."

Copernicus, now nearing seventy years of age, at length determined to publish his completed work. He inscribed his Preface, "To the Most Holy

Lord Pope Paul III", Osiander wrote an anonymous foreword, and Rheticus arranged that the book should be printed at Nürnberg. Soon after this Copernicus was stricken with paralysis from which he never recovered though he lingered on for a few months. On May 24, 1543, the first copy of *De Revolutionibus* was received from the publishers. It was placed in his hands. He saw it and was glad. A few hours later Copernicus was dead.

Four hundred and thirty years ago the words of Osiander supplied a temporary and partial camouflage for the dynamite which the book contained. Copernicus had written,

> First and above all lies the sphere of the fixed stars, containing itself and all things, for that very reason immovable; in truth the frame of the universe, to which the motion and position of all other stars are referred. Though some men think it to move in some way, we assign another reason why it appears to do so in our theory of the movement of the earth. Of the moving bodies first comes Saturn, who completes his circuit in xxx years. After him, Jupiter, moving in a twelve year revolution. Then Mars, who revolves biennally. Fourth in order an annual cycle takes place, in which we have said is contained the earth, with the lunar orbit as an epicycle. In the fifth place Venus is carried round in nine months. Then Mercury holds the sixth place, circulating in the space of eighty days. In the midst of all dwells the Sun. Who indeed in this most beautiful temple would place the torch in any other or better place than one whence it can illuminate the whole at the same time? Not ineptly, some call it the lamp of the universe, others its mind, others again its ruler – Trismegistus, the visible God, Sophocles' Electra, the contemplation of all things. And thus rightly in as much as the Sun, sitting on a royal throne governs the circumambient family of stars ... We find, therefore, under this orderly arrangement, a wonderful symmetry in the universe, and a definite relation of harmony in the motion and magnitude of the orbs, of a kind which it is not possible to obtain in any other way. (*De Revolutionibus*, Bk. I, Chap. X.)

"In the midst of all dwells the Sun." He postulated three motions of the Earth, (i) a diurnal rotation from west to east about the polar axis; (ii) an annual revolution about the Sun in the plane of the ecliptic; (iii) a variation in inclination of the Earth's axis to the line joining Sun and Earth. Thus he explained the apparent daily rotation of the heavens, the apparent annual motion of the Sun through the constellations of the Zodiac, and the cycle of the seasons. He discussed the motion of the moon as a satellite of the Earth. He dealt with the motions and relative positions of the two inner and three outer planets, explaining their sidereal and synodic periods. He affirmed the extreme distance of all the stars, so great that the Earth's orbital motion produced no apparent parallactic shift of the stars. All this was elaborated with diagrams and position tables, and a weight of evidence so great as to leave no careful reader of *De Revolutionibus* with any vestige of doubt but that Copernicus intended his heliocentric planetary theory to be regarded as a statement of physical fact.

Small wonder, then, that when the far-reaching significance of this book was realized, timid, bigoted and intolerant ecclesiastics denied its implications and discouraged the study and discussion of its arguments by threat of torture and the stake. It was not, however, placed upon the Index until 1616, but there it remained until 1835.

William Gilbert in England and Giordano Bruno in Italy, both born in the 1540's, became the first notable men outside central Europe to convince themselves that a new light had dawned in astronomical thinking, and a new universe lay open to the eyes and minds of men. Gilbert advocated the Copernican theory and lived to publish his famous *De Magnete* and to die in 1603 respected and honoured in Elizabethan England. But Bruno's advocacy of the same theory placed his life in jeopardy. He escaped from Italy and proceeded to expound the Copernican cosmology and his own somewhat pantheistic but rather beautiful philosophy in Geneva but fled the intolerant disapproval of Calvinism. In Paris and later in Oxford and in Wittenberg he discoursed upon the new theory, being generally opposed but arousing interest in it wherever he went. Lured back to Italy on a promise of freedom to think and teach what he believed true, this scholarly disciple of Copernicus in science and of von Cues and Ramón Lull in philosophy went to the stake in Rome in 1600 for his advocacy of new ideas.

Sixty-seven years after the death of Copernicus Galileo placed the Copernican Theory on so firm a footing of new astronomical observations that his name stands linked with those of Copernicus before him and Sir Isaac Newton following him at this great turning point in the history of human thought.

Thus Copernicus and his book ushered in the renaissance of learning in astronomical science. During the centuries which have followed, knowledge has grown from more to more. Copernicus had displaced the Earth from the centre of the Universe and man's abode had become a minor planet. In a later century the Sun and planets were removed from a central position in the stellar universe to an inconspicuous place more than half way out along a radius of the Milky Way system. In our own century our galactic system has become only one of many million stellar galaxies. Circles gave place to Kepler's elliptic orbits three centuries ago. Nothing now remains static, neither earth nor sun nor stellar galaxy, not even the framework of space itself in the Lemaîtrian speculations of an expanding universe.

The repercussions of the Copernican cosmology upon philosophy were inevitably far reaching, though Copernicus himself seems not to have realized the full implications of his work in this respect. His great successor, Galileo, boldly drew the inferences – if a geocentric cosmology had to be abandoned, anthropocentric philosophy must likewise go. Henceforth the man of science must investigate nature with complete objectivity. Philosophy

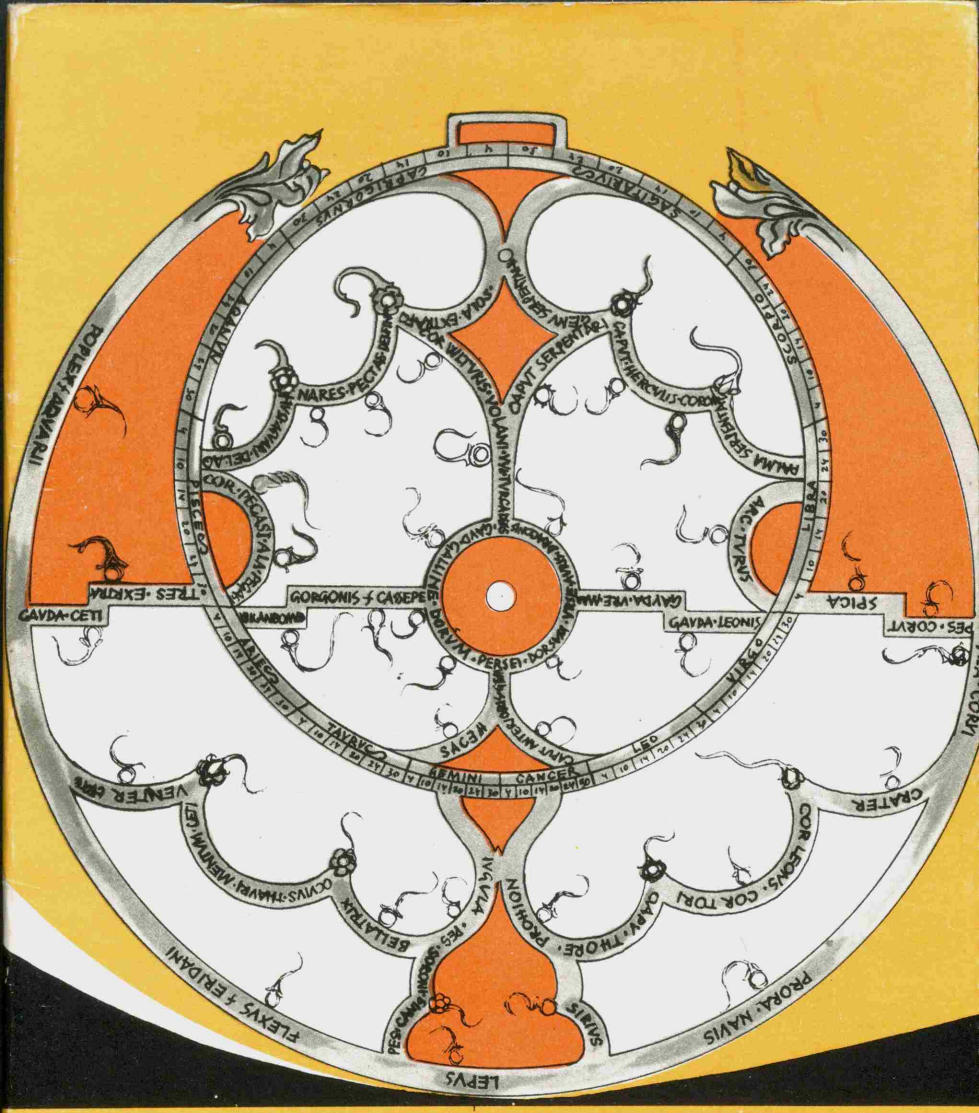
It had seemed natural to assume that

must break away from the shackles of teleology ~~focused upon man~~ focussed upon Man. Man was no longer obviously of prime importance as had been so easy to assert in the ancient world with its geocentric outlook. For man the sun and moon rose and set, for him the stars shone forth, for him the rains fell and the earth produced her increase – "Thou madest him to have dominion over the works of Thy hands, Thou hast put all things under his feet". If today man be regarded as of great intrinsic worth, it is not because this is an inevitable deduction from a survey of the physical universe, ~~it must be for intellectual and spiritual reasons. Such reasons, happily, are not wanting when we study the character, achievements and influence of such men as Copernicus, men filled with courage and with "the divine afflatus of the truth-seeker".~~

Thus Copernicus started balls rolling in more directions than one – and they are still rolling with ever increasing momentum.

and Kepler replaced circular orbits by ellipses. Their names stand linked with that of Copernicus at this great ...

In 1687 Newton's Principia completed the picture.



COPERNICAN RELICS

IN JAGELLONIAN UNIVERSITY

COPERNICAN RELICS
IN JAGELLONIAN UNIVERSITY

COPERNICANA CRACOVIENSIA

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KAROL ESTREICHER

Copernican Relics in Jagellonian University

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COPERNICAN RELICS IN JAGELLONIAN UNIVERSITY

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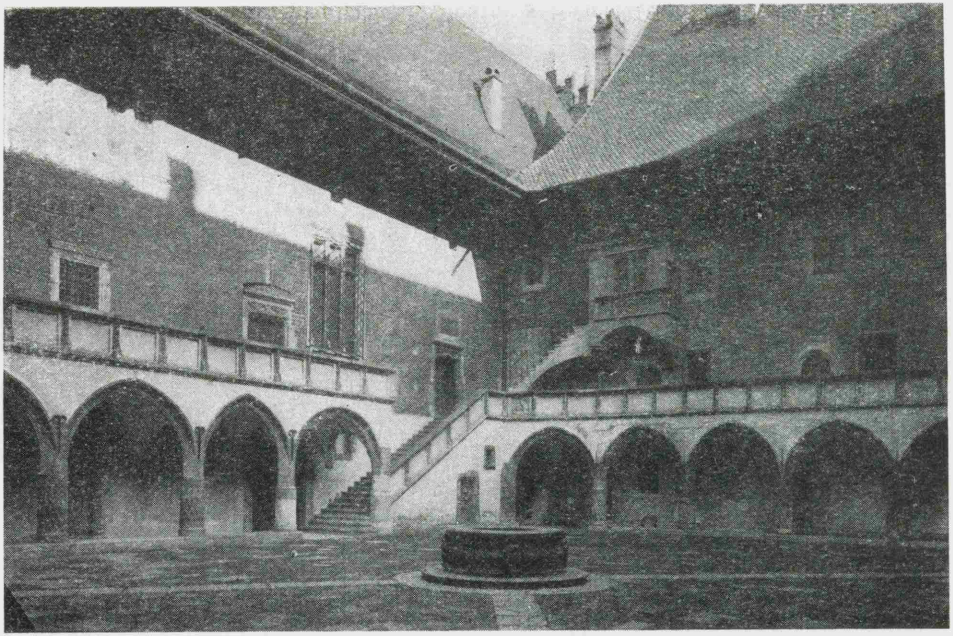
Copernicus, this most eminent of Jagellonian University alumni, had not long to wait to be recognized at, his first college. Later, in the course of the seventeenth and eighteenth centuries, this recognition evolved to become a sort of cult. All relics with a bearing on his person and work have been always carefully sought for and collected.

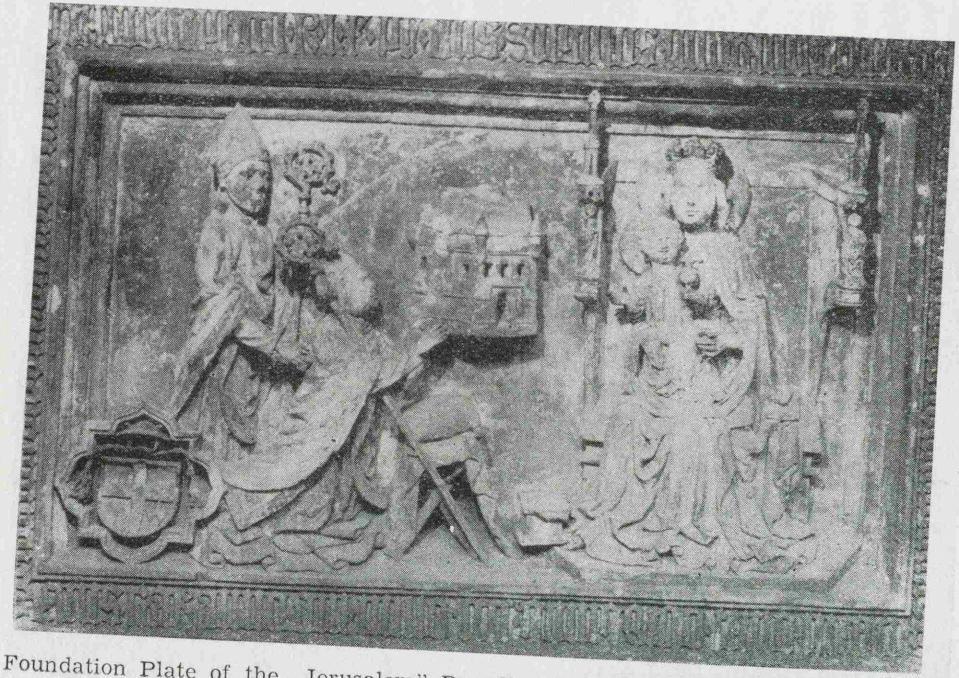
Like it is the case with every strong personality, Copernicus had to face opposition still in his lifetime: his ideas were contested and ridiculed, the founders of the Reformation condemned him and called him a conjuring impostor, and later (1616) also Rome condemned his teaching. In 1541 a comedy was published at Gdańsk by the Dutchman Wilhelm Gnapheus, with an attack against Copernicus and his ideas, a fact which took place two years before his death. However, some scholars are of the opinion that the comedy was directed not so much

against Copernicus himself, as against the Roman Church in general, since the comedy showed a great affinity with the Reformation trends. Anyway, it was also owing to this comedy that after the death of the astronomer nothing was done to commemorate him by an impressive tombstone and that in course of time his intellectual heritage came to be dispersed. It must be stressed, though, that there are no copies extant of Gnapheus' comedy at Jagellonian University, and that probably they had not reached Cracow at all. Maybe just because Copernicus and his teaching had found a high appreciation still during his lifetime in our academic city.

In 1503 Copernicus finally came back from Italy to Varmia to work there in comparative seclusion as a physician, administrator of the chapter, diplomat, economist, and scholar in the fields of astronomy, geography, and philology. All his life was controlled by reason. Of serious disposition, silent and withdrawing, unlike most humanists, he rather shrunk from the exuberancies of the Renaissance. He had solid ties with Cracow and its University, still reinforced with his recurrent visits to the capital city of Sigismund I the Old. In Cracow he was in scholarly contact with Marcin Biem of Olkusz, mathematician and reformer of the calendar, with Nicolas Procopiades of Szadek, the famous astrologer of that time, with Bernard Wapowski, the eminent geographer, and other scholars. These were, too, the earliest disseminators of his teaching and of his fame. Then, after his death, in 1551 Hilary of Wislica, a Cracow scholar, founded his astronomical calendar on Copernican tables; somewhat later, the heliocentric theory of Copernicus was expounded by professor Walenty Fontana. Also his truest follower and supporter



A 15th-Cent. View of the Collegium Maius Courtyard



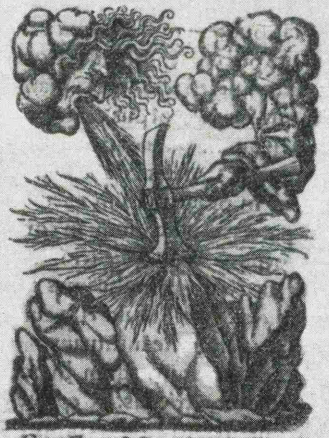
The Foundation Plate of the „Jerusalem" Boarding School (15th cent.), Collegium Maius

NICOLAI COPERNICI TORINENSIS DE REVOLVTIONIbus orbium cœlestium,

Libri VI.

IN QVIBVS STELLARVM ET FIXARVM ET ERRATICARVM MOTVS, EX VETEribus atq; recentibus obseruationibus, restituit hic autor. Præterea tabulas expeditas luculentasq; addidit, ex quibus eosdem motus ad quoduis tempus Mathematum studiosus facillime calculare poterit.

ITEM, DE LIBRIS REVOLVTIONVM NICOLAI Copernici Narratio prima, per M. Georgium Ioachimum Rheticum ad D. Ioan. Schonerum scripta.



Cum Gratia & Priuilegio Cæs. Maiest.

BASILEAE, EX OFFICINA HENRICPETRINA.

The Title-Page of Copernicus' *De revolutionibus orbium coelestium. Property of Jagellonian Library, Cracow*

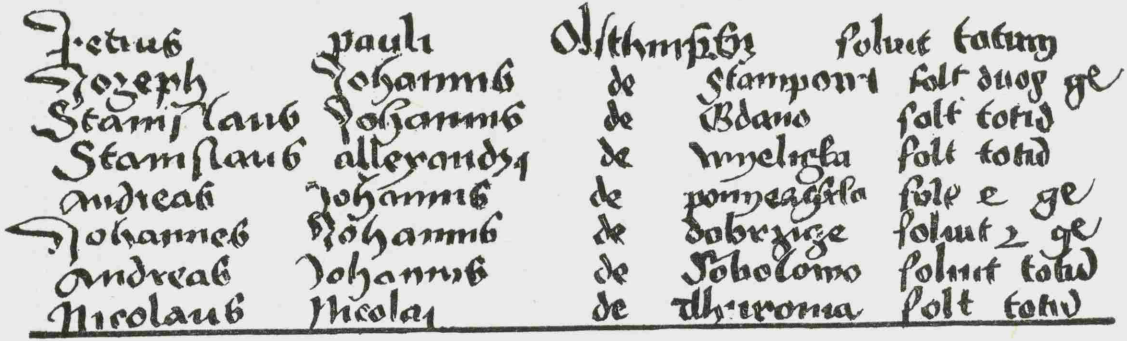
George Joachim Rheticus, the well-known editor of *De revolutionibus*, came to settle in Cracow and stayed there for long years. With some intervals, and perhaps not without obstacles, Copernican fame was constantly spreading in the town. In 1563 the professors of Cracow observed the conjunction of Jupiter and Saturn, having calculated it according to his tables, and emphasizing the great significance of the Copernican theory. In 1629 Brożek recorded that he had come across the works of Copernicus at Jagellonian University, probably thanks to Professor Jan Muscenius.

I

We shall now consider, what exactly has been left of Copernican relics at Cracow University, both those directly and indirectly connected with his person and work, from ancient buildings down to small objects (books and MSS., statues and instruments, portraits and works of art).

The number of these relics is surprisingly high. We would like to stick to our division into "directly" and "indirectly" connected relict, the latter group comprising later tokens, serving to ilustrate his life and work — and the respect bordering on worship he has enjoyed for centuries in our town.

Three mediaeval university colleges, Collegium Maius, Collegium Minus, and Collegium Iuridicum, have survived till the present day, though they have been considerably altered since the astronomer's times. It is highly probable that another college, the Collegium Medicum is hidden within the walls of two old houses in Grodzka Street.

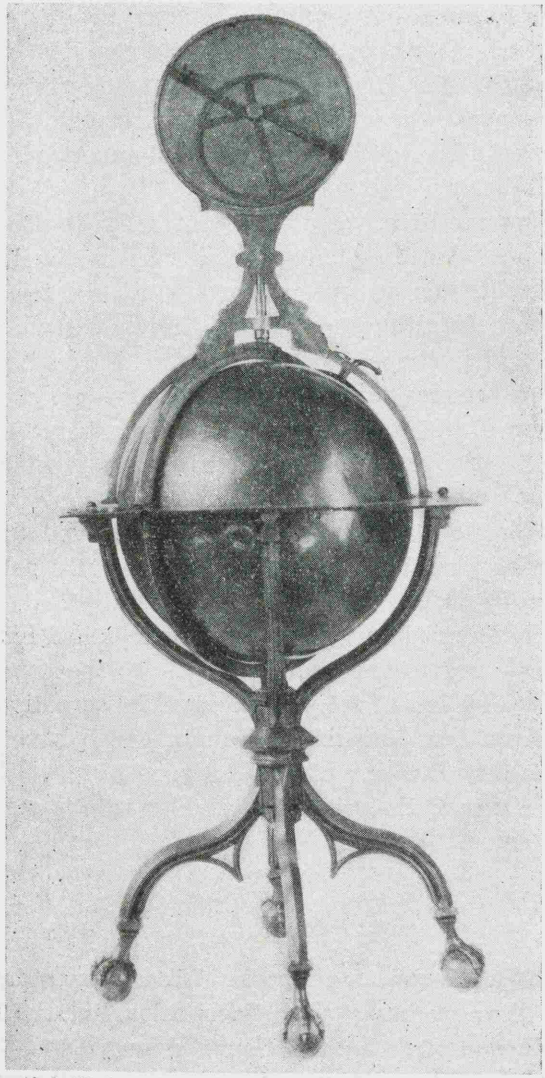

Petrus paul Olsthmpth solvit totum
Joseph Johannis de Stampovi solt duos ge
Stanislaus Johannis de Bdano solt totu
Stanislaus alexandri de Wielicka solt totu
Andreas Johannis de pomeaghla solv e ge
Johannes Johannis de dobrzize solut 2 ge
Andreas Johannis de Sobolomo solut totu
Nicolaus Nicolai de Thuroma solt totu

Copernicus' matriculation in the *Metricae Studiosorum* for the Winter Term, 1491—1492. *Property of Jagellonian Library*

The most outstanding of all University Houses is Collegium Maius, a splendid and indeed unique example of university architecture on a world scale. Now it looks like a Gothic building raised on a rectangular plane with an arcaded courtyard in the middle, showing a great likeness to Italian colleges and city palaces. By its style the College is a forerunner of the Renaissance. The arcaded courtyard, the tall windows, the stonemasorry of the framings seem to indicate that its builders were to a certain extent familiar with ancient architecture. The style had unmistakably come from Italy, like the Polish humanistic trend. About the same time when Copernicus came to study at Cracow University, the courtyard of Collegium Maius, and the whole building with it, were restored in this spirit. The man in charge of the restoration works was the architect Johannes, in all probability native of Cologne, but the halls were designed, interconnected, and arranged according to the wishes and tastes of the professors.

From the south, where now a fully detached house, the Libraria (early sixteenth century) is standing, a two-storey building was joined to the Collegium Maius, with a not too steep pent-roof. On the roof facing in the south-western direction there was an astronomical observatory during the fifteenth century. One could see from there a wide circle of the sky far up to the hills of the Sikornik, Chełm, and Zabierzów. The whole area was not built-in, being covered with the marshes of the Rudawa River. Up to the end of the nineteenth century the roofs of Collegium Maius offered a vast and distant view.

When Copernicus was studying at the University, in the Collegium Maius lecture-rooms lectures were



The Celestial Globe of Marcin Bylica of Olkusz (1480). *Property of Jagellonian University Museum*

going on despite the restoration works, probably on the ground floor. It is an attested fact that then the students used to sit, not on low stools, but on brick prepared for the stonework; the professors were complaining to the Rector that after the lectures the students forgot to take those bricks away from the halls.

The lectures were held not only in Collegium Maius, but also in Collegium Minus, as well as in Collegium Juridicum and in several students' dormitories in the town. In all probability Copernicus knew all these houses, and perhaps he lived at one of the boarding-schools or "burses" as they were called — maybe in the Jerusalem Burse which was standing where now the Collegium Novum is. From this Burse, which was destroyed late in the nineteenth century, a fine foundation stone has been preserved; carved in stone, it has been now built in into a wall of the Collegium Maius courtyard.

We do not know where Copernicus had his abode in Cracow and it does not seem likely that we might learn it at any later date. If, however, he actually stayed at a students' boarding-school, he might well have chosen the Jerusalem Burse, which had a good library allocated to it by a gift of Zbigniew Oleśnicki, and was generally well endowed.

II

In 1955 the Jagellonian Library acquired, as a result of an exchange with Czechoslovakia, the MS. of *De revolutionibus*, which had once belonged to Rheticus. The detailed description of the MS., of its external appearance, its lettering and its drawings, lies beyond

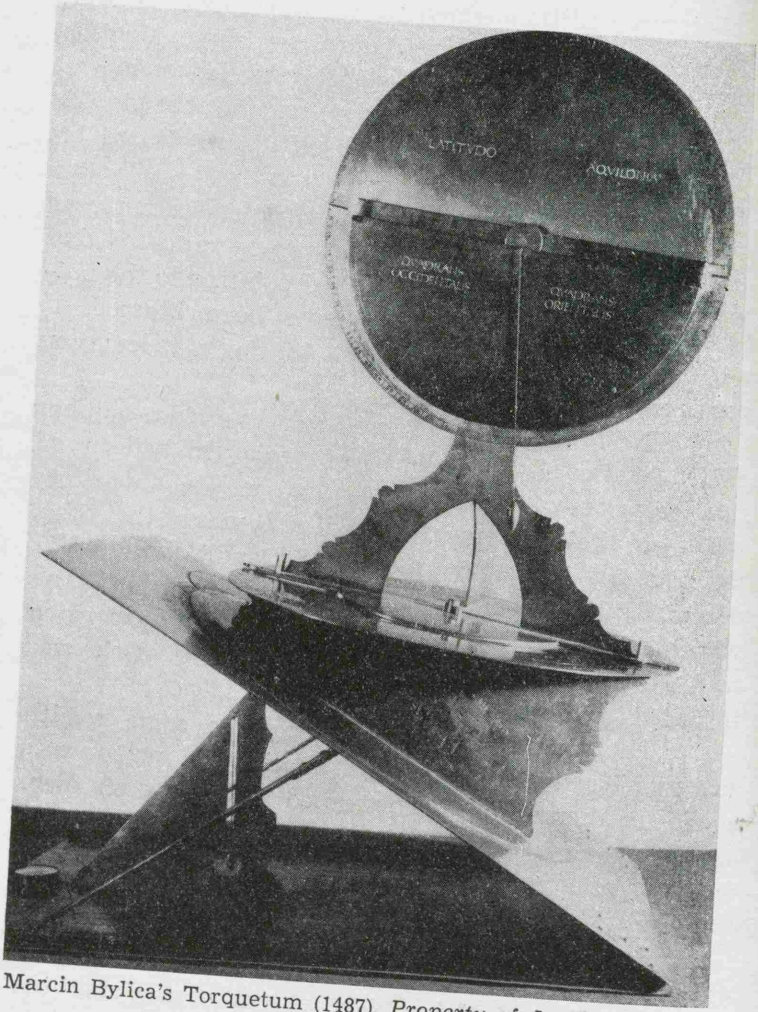
the scope of the present subject; besides, there is a phototypic edition which makes it possible to study this work of priceless value. Here we must mention, however, that Copernicus was highly skilled in the art of fine lettering and technical drawing, and that his MS. bears witness not only to his genius, but also to his artistic gifts.

Of great value is also his matriculation record in the University Books (1491). It is to be regretted that as a result of constant handling and pointing to the not-too-legible record, the letters have been blurred. It would be good to have this page in the matriculation book recopied.

The Jagellonian Library has preserved a number of MS. treaties of the fifteenth century which had served the professors of Copernicus — and maybe himself as well — in their astronomical studies. It was at that time, too, that the University purchased Dondi's Italian MS. describing in great detail, and with drawings, the workings of the tower clock. It was probably according to that manuscript that an hour-striking clock was installed in Collegium Maius.

The professors who had acquired some wealth (as, e.g., Maciej of Miechów), had scientific instruments made for them or else constructed them on their own. As it appears from Maciej's Last Will and Testament, he had a number of instruments for the study of the sky and the stellar system.

Maciej's instruments have not been preserved, but those of Marcin Bylica have survived and are now on show in Collegium Maius. Kept with great care since the fifteenth century at the University, they constitute a highly valuable set of objects, unique in their kind.



Marcin Bylica's Torquetum (1487). *Property of Jagellonian University Museum*

The most prominent object of all is the celestial globe.

Marcin Bylica of Olkusz was a student at Cracow University since 1452. For a brief time he lectured at it (1459), then he went to Italy, to lecture in astronomy at Bologna. In 1564 Bylica undertook astronomical research in Rome, together with another famous astronomer, Regiomontanus (native of Königsberg) Later (1467) he went to Bratislava, where he was appointed professor at the newly-founded University. In course of time he became Court astrologer to Matthew Corvinus, King of Hungary. Shortly before his death (1493) he bequeathed his books and astronomical instruments to his first uniersity, i.e., to Cracow. In October 1494 Bylica's nephew Stanislaw (died 1515) brought them to Cracow. The professors put these objects on show, convoking all University members to come and visit the exhibition.

Marcin Bylica's celestial globe consists of several parts. No particular skill is needed to observe that the parts differ from each other. The globe is supported on four clawed legs, each of the claws holding a sphere. The latter are meant to symbolize motion, the variability of the system and human fate. The legs of the base become Gothic arcs, bound in a knot (the *nodus*); then they separate again forming a base upon which a square sundial face is reposing. Through a cut-in hole the celestial globe proper has been inserted, with the ecliptic disk and the images of the constellations. There is a handle on one side which permits to move the globe so as to see the respective disks. But this is not all. An astrolabe has been set above the celestial globe with a scale allowing to measure the mutual stellar angles. This (third) part seems to have been added later on.

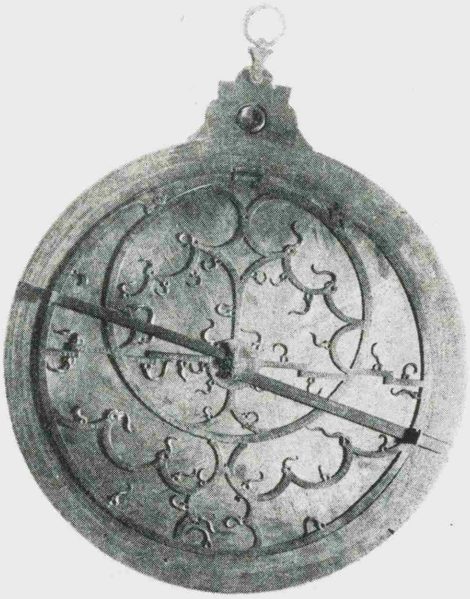
On Bylica's globe we can see the "Poraj" of-arms, the sign of the Sagnittarius constellatio well as some inscriptions and the date 1480. All t data refer to Marcin Bylica of Olkusz.

On the decorative bands we can read a leg stating that the hour will be read — in sunlight — w the hand with the thread is set according to the sc Also the altitude can be read in this manner.

Another instrument which had belonged to Ma cin Bylica and is of prominent value is the torquetu i.e., an instrument also composed of plates and scale discs, with a circle of ecliptic co-ordinates from a sun -dial with a magnetic needle, which was an object o wonder at the time as a mysterious indication pointing to the north. Bylica had owned also a fine astrolabe made in the fifteenth century (perhaps French?) with several scaled dials which was also used to calculate the stellar angles.

Until 1953 Bylica's torquetum was kept at the astronomical observatory in a disassembled state, some of its plates added to other instruments. Then it was carefully reconstructed and re-assembled after a design by Dr. Tadeusz Przypkowski.

It is not known for certain, where and by whom these two mentioned first complex astronomical instruments have been made. The historians of science have suggested — and the idea seems very likely — that the author of these instruments was the Dominican Friar Hans Dorn of Vienna, a specialist in the construction of instruments and tools. In Bylica's globe certain stylistic features as well as the way in which the constelations have been presented, seem to point to Arabic traditions, whereas the inscriptions, scales, and



Marcin Bylica's Astrolabe (c. 1480). *Property of Jagellonian University Museum*

indications show that the constructor of the instruments must have lived not far from Hungary where Bylica was active. Dorn's Viennese workshop seems to be the most likely place.

Bylica's set of instruments includes equally a small Arabic astrolabe (with a legend in Arabic), constructed in 1054. If the young Copernicus was given access to Bylica's instruments, he must have known also the Arabic astrolabe. This is certainly one of the oldest relics of this type, and still at the time of Copernicus it was held in great esteem. Now, of course, its value has not decreased. In 1958 it was even lent over to the Paris

Arabic Astrolabe (1054). *Property of Jagellonian University Museum*

exhibition, "East and West", which was devoted to the cultural and scholarly relations between the two parts of the world.

Made in bronze, it contains several plates with additional disks. A legend in Arabic is written on the central dial, with a Latin one (a later addition) close by. In letters, the main legend reads (transcribed): iubi a bi-Kurtuba fa-kamula bi-awn Allahi ta ala fi sanati ta-mini-waw; (in English:) "Stamped at Cordova and com-

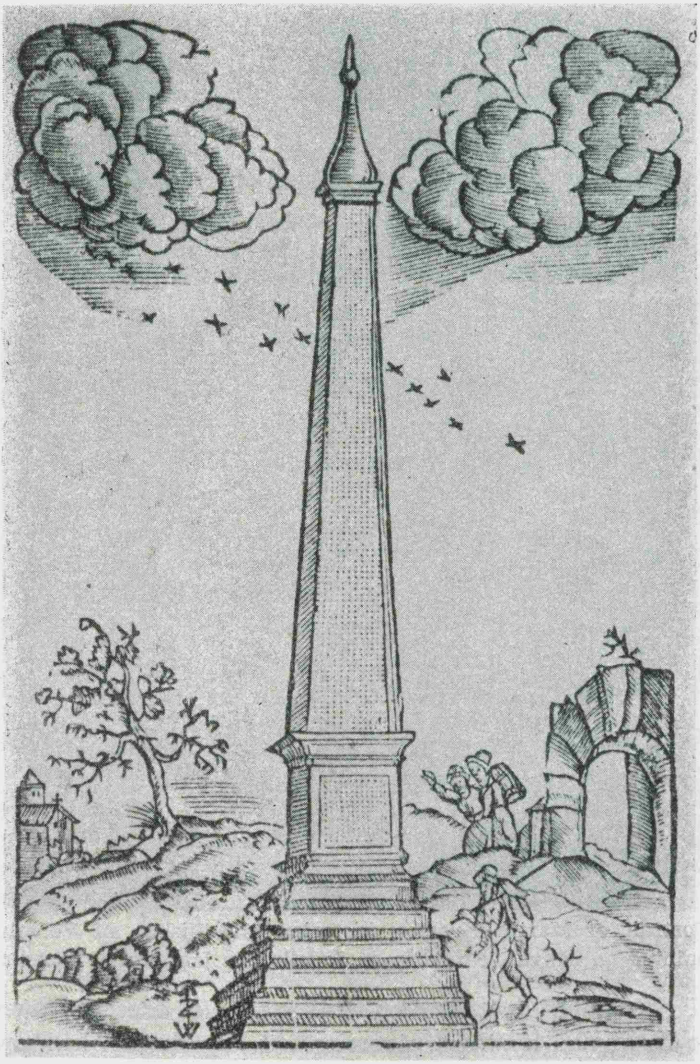
pleted with the aid of Allah — he is exalted — in the year 446".

What is the relation of these objects to Copernicus?

In his Last Will and Testament, Marcin Bylica bequeathed these instruments to Collegium Maius. They created a genuine sensation: on their arrival to Cracow Rector Sacranus granted a day off to the University so that every scholar might take a proper look at them. Then for many years they were exhibited at the Collegium Maius, and many eminent guests were invited to visit them. In 1510 the envoys of Emperor Maximilian expressed their admiring appreciation of Bylica's astronomical instruments, regarding them as an exhibit of unique value.

It has been already mentioned that in the fifteenth century the astronomical observatory was in all probability located on the roof of the house adjoining Collegium Maius from the south. There are archival records to prove it, though coming from later years. On the other hand, one can hardly imagine any other place at the Collegium Maius from where one could observe the sky; and neither it is to be imagined that the heavy and hard-to-move instruments might be handled without an observatory specially adapted to these ends. It was probably to have an easier transport for the instruments that a staircase was built at the time when Copernicus was attending the University. The staircase has been preserved and is now leading on the outside of the Collegium (near the portal to the library) to the second floor of the building: while then it was leading on to the roof of the adjoining house.

The Jagellonian Golden Globe (c. 1510). *Property of Jagellonian University Museum*



Rheticus' Obelisk, a 16th-cent. woodcut engraving. *Property of Jagellonian University Museum*

Portrait of Martin Kromer, historian and Bishop of Varmia, painted on canvas. *Property of Jagellonian University Museum*

But Bylica's instruments were not the only ones to be owned by the University. At Jagellonian Library one can find fifteenth-century treaties about the use of instruments, of astrolabes in particular. Students were

also taught to handle astronomical instruments. They, too, probably used to construct some makeshift astrolabes on their own, in wood, parchment, or even in simple paper. If in later years Copernicus at Frombork was able to produce astronomical instruments — or else to instruct somebody who did it for him — then he probably had acquired the first principles of this skill at the University of Cracow. There are good grounds to suppose that in his student years Copernicus was acquainted with Bylica's instruments and even used them. It has even been suggested that in later years when he was a famous astronomer Copernicus might have borrowed Bylica's instruments to Varmia. Anyway, Bylica's set of instruments can be regarded as relics closely connected with Copernicus, though they certainly were not his property.

To what extent, if any, Copernicus was familiar with the so-called Jagellonian Golden Globe, bearing the inscription: *America noviter reperta* — it is difficult to say, since the date on which this object was acquired by the University collections, is quite unknown. The globe itself is really an intricately constructed clock revolving round the armillary sphere: it was made early in the sixteenth century (ca. 1510), at a time when Copernicus had been living at Frombork, but came recurrently to visit Cracow and — the fact has been attested — had good relations with the scholars in this city.

In *De revolutionibus* there is a passage in a way connected with the imagery on the globe, namely with the discovery of America. Copernicus wrote about "...islands discovered in our times at the instance of the Spanish and Portuguese rulers, and above all about

America, called so after the admiral who had discovered her and regarded, with her dimensions as yet unknown, as another continent". It does not result from the quotation that Copernicus was familiar with the Jagellonian globe, but the possibility is not to be excluded.

III

Towards the end of Copernicus' life a prominent part was performed by his disciple, George Joachim Rheticus (1514—1574). It was due to his solicitations that the work of the Polish astronomer was published in Nürnberg in 1542. In 1554 Rheticus came to settle in Cracow where he carried out medical practice and where also to increase his revenue he dabbled in astrology. But his main concern was mathematics, and his preferred field of study — trigonometry. As a disciple of Copernicus he enjoyed great renown, also outside Poland. At Copernicus' instigation he undertook an investigation of the salt-mines at Wieliczka, a fact duly recorded by Jan Brożek.

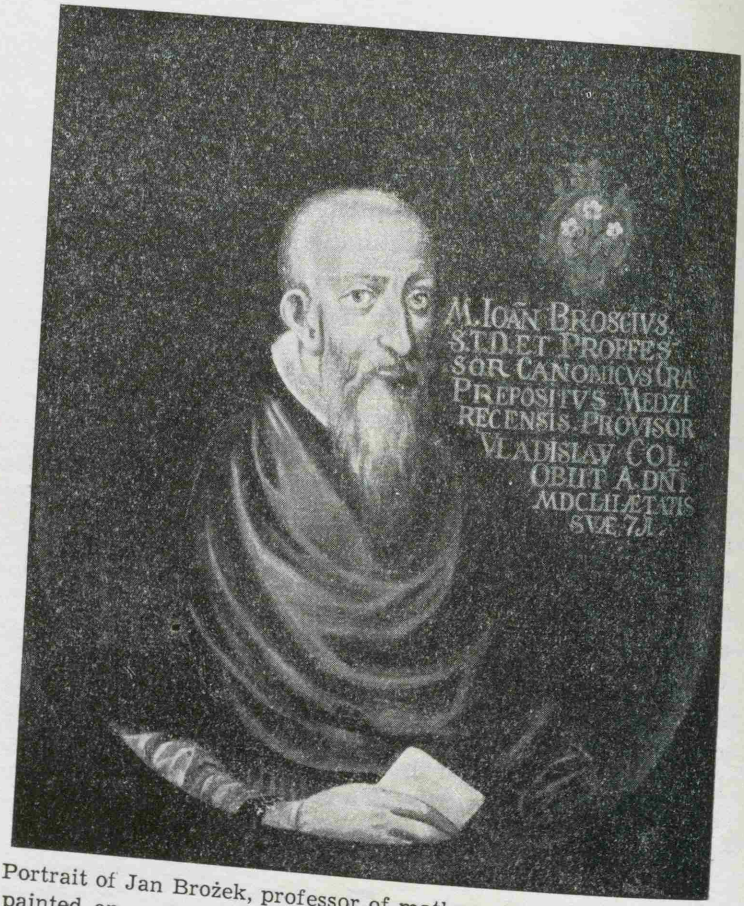
In one of his mathematical works Rheticus wrote: "This reason for the anomalies in the orbit of permanent stars was first discovered by Nicholas Copernicus, this Hipparchus of our times whom one cannot praise too much. I have dwelt on it at length at another place. When after a nearly three-year stay in Prussia I was about to leave, this venerable old man bound me in duty to try to complete what he could not perform both because of his old age and of some ill fate. These studies are of the greatest importance, and the assignment to carry them through was transmitted to

us by Mr. Copernicus whom I have venerated and respected not only as a teacher but as a father, and it has been always my wish to show him my gratitude. Thus, having duly studied geometry and arithmetics, I chose Cracow as my place of observation, for Copernicus has discovered that Frombork — where his observations had been made — is situated at the same distance from the west as Cracow is, and lies on the same meridian... Here owing to the bountiful aid on the part of the Right honourable Jan Boner I raised an obelisk, forty-five Roman feet high. For it was my opinion that no other instrument could be better suited..."

There is a mention in Professor Stanisław Pudłowski's records kept at Jagellonian Library stating that the obelisk in question was standing in the "Garden of the Heretics" (in all probability, somewhere in the "Wesoła" suburb, near the Copernicus Street of today) and that it was demolished by the students, probably in 1574. But the printing-office of Rheticus' friend Jan Januszowski, took the effigy of this obelisk for its emblem, and this has permitted us to surmise how it looked like. Finally, in the collections of the Jagellonian University Museum there is a wood-cut dating from the sixteenth century, with a view of the obelisk.

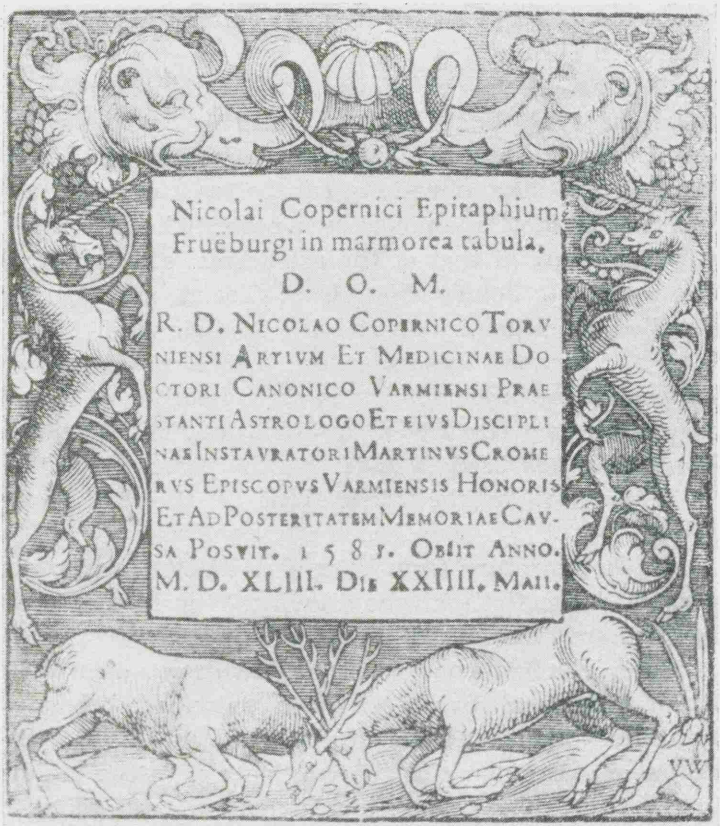
IV

Copernican fame and renown were constantly growing. In 1580 Martin Kromer, the Bishop of Varmia, placed an epitaph near his tombstone in the Frombork Cathedral. The Danish astronomer Tycho Brahe organized a special expedition to Gdańsk and Varmia in 1584, sending to Frombork his disciple Elias Cimber



Portrait of Jan Brożek, professor of mathematics and astronomy, painted on canvas. *Property of Jagellonian University Museum*

to test the Copernican latitudinal observations on the spot. From the Frombork Chapter Cimber obtained the astronomer's MSS. as well as his portrait and instruments. No doubt the scholars of Cracow knew about the



Epitaph to Nicholas Copernicus of Frombork: woodcut engraving (1620). *Property of Jagellonian University Museum*

expedition and it was probably in this connection that in 1618 Jan Brożek went to Pomerania to collect the Copernican relics. He brought back the letters (regrettably, no more extant) written to Copernicus by Dantyszek, Rheticus, Wapowski, Watzenrode: he had also the astro-

nomer's portrait re-copied from his epitaph in St. John's Church in Toruń.

How great was Brożek's veneration for Copernicus and everything that had a bearing on his person, how anxious he was to include every Copernican finding in the University collections, can be testified to by the fact that beside Copernicus' own portrait he commanded also a copy of that of the astronomer's father from the same St. John's Church at Toruń and, having supplied the legend, had it hung in Collegium Maius. It was at Brożek's instance, too, that a biography of Copernicus was included in the second edition of Simon Starowolski's *A Hundred Biographies of Polish Writers*. Finally, Brożek used to underline the passages relating to Copernicus in the MSS. kept at the University Library.

On his return from Varmia (ca. 1620) Jan Brożek published a leaflet with the drawing, "Nicolai Copernici Epitaphium". The finely designed frame has two heads of Indian elephants on top, lower down two unicorns on either side, and two deer with entwined horns — fighting — at the bottom. The letters V W on the right side denote the name of the woodcutter. In the middle of the frame there is a legend which we are going to quote in its English translation:

"Epitaph of Nicolas Copernicus at Frombork on a marble plate.

"To our Lord the Supreme.

"To the Honourable Master Nicolas Copernicus native of Toruń, Doctor of Art and Medicine, Canon of Varmia, Most Excellent Astrologer and Founder of this Science, Canon of Varmia, Martin Kromer Bishop of Varmia In His Honour and that He May Be Remembered

by the Generations to Come Laid [Here] 1581. He died in 1543, on May XXIII."

In 1629 Jan Brożek published in Cracow in Franciszek Cezary's printing-office a poem wrongly attributed to Copernicus, the *Septem Sidera* (Seven Stars). Brożek preceded his work by a preface addressed to Pope Urban VIII, probably to win over the Pope to the Copernican ideas and work, the whole poem being markedly religious and even mystical in character.

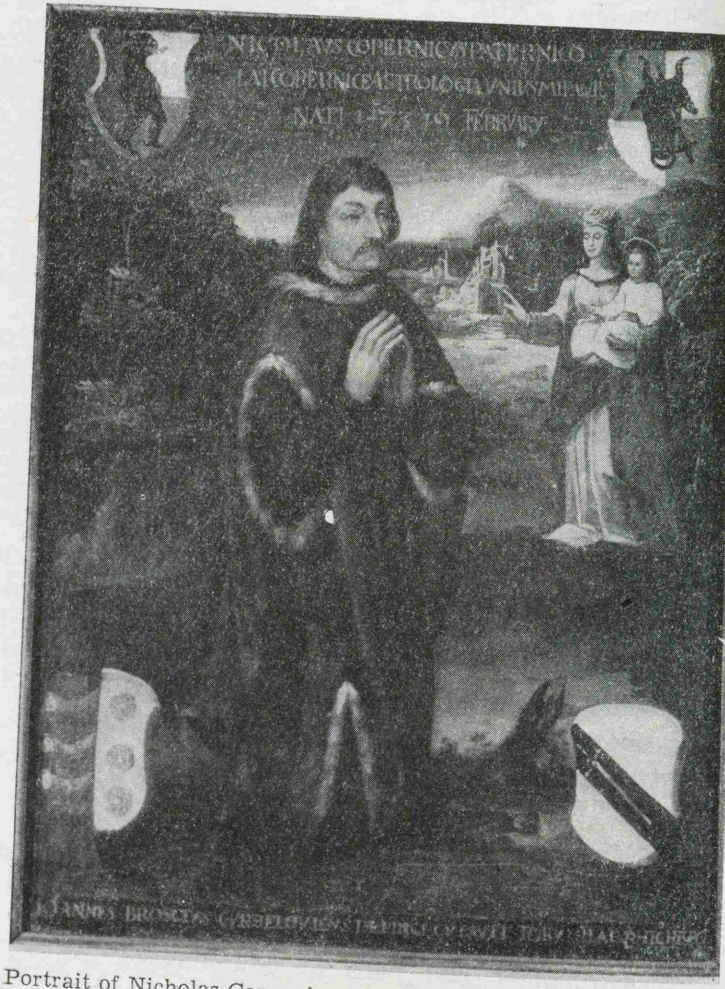
Our main concern, however, is not the poem itself but the said preface, where Brożek noted how for long years he had been looking for Copernican relics and how eventually he had come across the astronomer's poem. It should be stressed, moreover, that in the same preface Brożek pointed out that Copernicus had been educated at Jagellonian University.

"Hoc artis arcanum per aliquot iam manus a Copernico in Academia Jagellonica iuit. De quo cum ego a praeceptoribus secreto didicissem; ut certoria haberem in Prussiam abii."

In English: "These arcana of science by Copernicus' hand were introduced into Jagellonian Academy; when this was conveyed to me by my masters, to verify it I went to Prussia [...]".

In 1615 Jan Brożek in a small book, *Epistolae* (published in Piotrowczyk's printing-office in Cracow) inserted epigrams about Copernicus; of these, one hexameter particularly deserves our attention since it proves how strong was the memory of the fact that the great astronomer had been an alumnus of Cracow University. These were the words attributed to him:

"Me genuit Torunia, Cracoviae me arte polivit — Inter habet primos Varmia clara patres" (English trans-



Portrait of Nicholas Copernicus' father, 17th-cent. copy. *Property of Jagellonian University Museum*

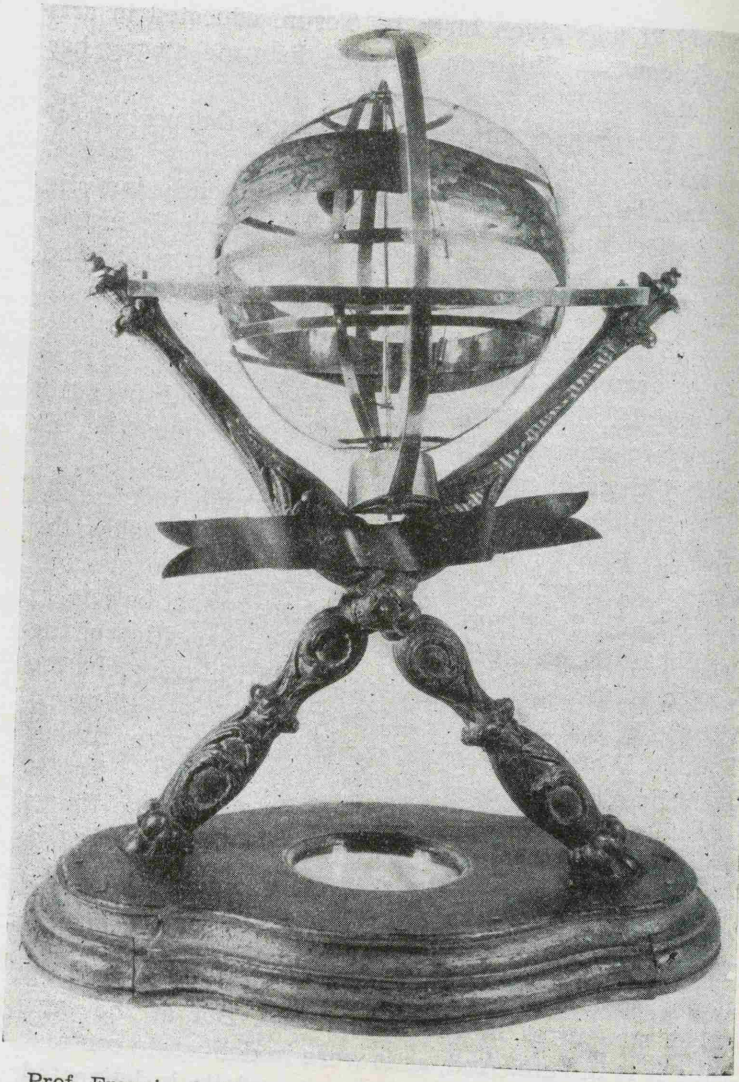
lation:) "I was given birth by Toruń, educated in arts by Cracow — illustrious Varmia lists me among her men of first rank".

Let us now proceed to examine the portrait of Copernicus' father which has been preserved at Collegium Maius. The portrait has been recently hung in the hall comprising Martin Bylica's astronomic instruments and other objects, as well as several portraits and drawings connected with Copernicus.

The original picture at Toruń in no more extant. It was drawn in the sixteenth century, somewhere near its middle. The present copy was painted in 1618. Therefore any suggestion on the subject must be set forth with great caution.

In the picture's front a young man is kneeling, with his hands joined in prayer. At his feet below the tree-trunk there is a cavity and the head of a salamander or snake, hardly visible, so that one cannot be certain which. In the background to the right, the effigy of the Virgin with Child, raising her hand in blessing. In the corner of the picture there are four coat-of-arms: Pomian, Watzenrod, Dryja, and Starzyna, drawn without great heraldic accuracy.

In the background of the picture strange things are happening. The Virgin is standing in a clearing in the woods on the ridge of a hill pointing out to a temple or tower dimly seen in the valley. The architecture of this temple or structure to which a staircase is leading, is Gothic and very monumental, just like that of the other structures in the background. But at the same time it is in ruin. And, as it were in deliberate contrast, behind the Virgin a Renaissance tempietto is delineated, surrounded with a columnade, and very much alike in



Prof. Franciszek Słupski's Armillary Sphere (1771). *Property of Jagellonian University Museum*

character to the small church San Pietro in Montorio in Rome. Where did this idea come from? Finally, deep in the background we can see rocky mountains, flooded in moonlight, for the scene is taking place at night.

The landscape shows traces of the influence of Dutch painting, with a simultaneous occurrence of forms typical of Italian Renaissance architecture. The painting is symbolic. The figure of the Virgin is not only her own effigy but also a symbol of the Church which is denoted by the name of "Mother". The ruins of a Gothic temple in the background symbolise either old pagan beliefs or the Old Scriptures, while the Renaissance round temples are a symbol of Christianity. What is the significance of the terrible head of the salamander heaving in sight from the ground, and is this an animal head really?

In the Middle Ages the salamander was considered a symbol of sin, damnation, and hell: but its implications in the picture are difficult to conceive. It must be constantly borne in mind that this is merely a copy.

The astronomer's father died young (1483), when Nicolas was just eleven. His effigy on the epitaph is young, too. It is probable that Nicolas Copernicus was himself the founder of the epitaph. Or perhaps he, himself with a knack for designing, had supplied the model for the portrait? This is quite likely. In the copy at the University Museum, Copernicus Senior shows a striking likeness to his son. This is no mere accident; it seems that the painter's hand was guided. Copernicus Senior is wearing a long coat resembling a gown or a tunic like the one Copernicus is wearing on the portrait on the Strassbourg clock, a fact which permits a later dating, though always remembering that this is a copy drawn in 1618. Since the family coats-of-arms

are drawn with great accuracy on the portrait, it seem highly probable that somebody must have supplied th model, and there are good grounds to surmise that i was the astronomer himself.

We must now discuss the legends: (at the top "Nicolaus Copernicus, Pater Nicoali Copernici Astrolo giae Unius Miraculi nati 1473, 19 Februarii"; (at the bottom) "Des heren Doctor Nicolae Copernick Thumher und Astronomus Zur Frauenburg seines seligen Vaters Auch Nicolaus Copernick genant, seine Gestalt — Joannes Broscius Curzeloviensis depingi curavit Torunii atque hic reposuit". Brożek had added the Latin inscriptions and his own name after the German text. On the original the German text was older, and it is quite likely that it was the only one to be inserted. It should be remembered that the picture was destined for the inhabitants of Toruń where at that time German was very popular in the streets, at school and at St. John's church.

Let us now proceed to discuss the second portrait Brożek had offered, i.e. that of the astronomer himself. The portrait was lost as early as the eighteenth century.

Just like it was with the astronomer's father's portrait, this too, was a copy of the epitaph — preserved in Toruń till the present day — bestowed by Doctor Melchior Pyrnesius ca. 1580. Pyrnesius, a native of Cracow must have inherited the appreciation — or rather veneration — for the Copernican memories from his professors at the University.

On the margin of one of the books at Jagellonian Library (1630) Brożek described the portrait and the legend on it, and added: "The monument was raised to Mikołaj Kopernik of Toruń, this mathematical genius, so that the memory of a man so famous among the alien

might not perish on his native soil. He died in Varmia as a Canon, on 24th May 1543. The portrait as it was painted at Toruń, was brought by me from Prussia and placed in the academic library alongside with the portrait of Kopernik's father."

In 1809 Prof. Józef Sołtykowicz in his erudite History of Jagellonian University mentioned the portrait, adding a valuable information that it was hanging behind a curtain. He accounted for the fact in a rather peculiar way: "The vivid image of this great man, was by Jan Brożek, a mathematician and professor famous at our Academy of Cracow during the early seventeenth century, hung for greater respect in the Library at the highest place behind a curtain".

Sołtykowicz remembered how the Library had been arranged in the seventies of the eighteenth century; for further information he applied to the former librarians Garycki and Przybylski who, though old, were still alive at the time of the publishing (1809). Thus there is no reason to doubt the veracity of the transferred information or to suspect Sołtykowicz of having mixed up facts about the curtain which was hiding the portrait.

On the other hand, it is not easy to account for the fact in any satisfactory way. What was the curtain for? To protect the portrait against light and dust? Then why was this protection not extended to other portraits, e.g., to that of the holy Cardinal Hosius?

It seems highly likely that the portrait of the astronomer was covered up during the seventeenth or eighteenth century because his work had been put on the Prohibitory Index as one which expounded views "meant to ruin the Catholic truth, Pythagorean — about the mobility of the earth and the immobility of the sun",

Portrait of Copernicus painted on canvas (18th cent.). *Property of Jagellonian University Museum*

as stated in the Index. It is probable that some librarian or other, reluctant to take the portrait off altogether, but fearing to put it on show, and hoping for better times, had hidden the portrait under a curtain. And this indeed would have been another proof (true, a rather unusual one) of the Copernican cult at Jagellonian University.

But who and when could have taken this portrait of the astronomer offered by Jan Brożek? When Przybylski took the Library in charge, the portrait was no longer there. When in 1785 the Library was visited by Frances Biron, Duchess of Kurland (nee Krasińska), she gave Przybylski a sum of money for which he was to paint a new portrait.

On the other hand, the portrait which the University had received from Brożek, was lost still before 1785; it must have been taken from the Library by some one who held Copernicus in high esteem and who wanted the portrait for some reason or other.

But, when he was ordering the two copies to be drawn, was the idea Brożek had in view only that the name of the great astronomer should be memorized for ever? Probably there was more to it. Just as he had concerned himself with the publishing of the religious poem, the *Septem Sidera*, attributing its authoriship to Copernicus and sending its copies over to Rome in order to reconcile Copernicus with those who had condemned his teaching; as, further, he had taken his letters probably to defend Copernicus against the imputation of heresy; — so also it can be supposed that the portraits, religious both in their mood and in their content, were to serve as proof of the astronomer's religiosity.

V

The Age of Enlightenment brought a revival of patriotic feeling, and this in turn stimulated national ambition. Just as it was in other parts of Poland, the University of Cracow also began taking a more vivid interest in national relics, among which the person of Copernicus and the relics connected with him occupied a prominent position.

Despite the papal prohibitions, Copernican astronomy in the course of the eighteenth century was generally admitted in Poland.

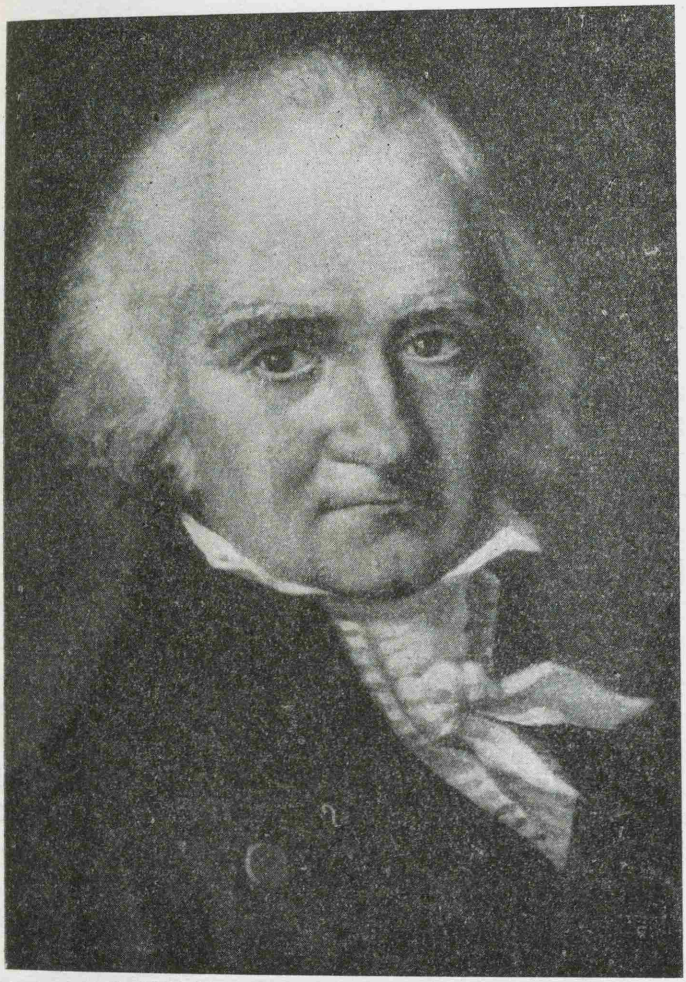
In Cracow the astronomer's fame did not abate, as can be testified to by a statement made by Professor Marcin Świątkowski in 1765, although on the other hand there were also some conservatively-minded supporters of the Ptolomean theory at the University (e.g., J. A. Putanowicz). An expression of these obsolete views and of a probable discussion on the subject is the armillary sphere made by Hugo Kołłątaj's teacher, Professor Słupski. The sphere, which has been preserved till the present day at the University Museum, shows a geocentric system of the sun and planets, supported on two University's sceptres.

In 1743 the second centenary of Copernicus' death was commemorated by a ceremony held at the Library of Leipzig University, quite unusual for that time. A speech in Copernicus' honour was delivered by Professor Johannes Christopher Gottsched who called him the immortal discoverer of the true structure of the Universe. The ceremony was attended by Andrzej Stanisław Załuski, Great Crown Chancellor of Poland, later Bishop of Cracow and Chancellor of Jagellonian University.

Model of the Copernican monument in Warsaw by B. Thorwaldsen. *Property of Jagellonian University Museum*

Leipzig was also the scene of activity of Józef Aleksander Jabłonowski, who in 1760 published in Lvov, and then in Gdańsk and in Rome, a pamphlet describing the Copernican heliocentric doctrine; he applied also to the Pope asking him to take the *De revolutionibus* off the Prohibitory Index. Jabłonowski founded an Academy at Leipzig which was named after him. He bestowed a marble bust of the astronomer on St. John's Church at Toruń (1766). The work was done in Cracow at Wojciech Rojowski's workshop and it bears Rojowski's signature. The bust was clearly modelled on the astronomer's portraits, perhaps on that which once had belonged to the University and is no more extant. There was, in fact, no other portrait of Copernicus at that time in Cracow, and neither was his effigy so easily to be got here. Anyway, the monument at once gave rise to some controversy, as the German inhabitants of Toruń did not agree to its being installed in the Church. It was not until the times of the Warsaw Duchy that Stanisław Staszic contrived to have a legend engraved under the monument.

But to return to the eighteenth-century portrait of Copernicus which was painted to Przybylski's order. Regrettably, its artistic value is not of the highest. Przybylski commissionned the work to some painter or other then living in Cracow (Łukasz Orłowski?) after the model of a drawing taken from Peter Gassendi's biography (1655), *Vita Nicolai Copernici*, which was appended to his work about Tycho Brahe. The frontispiece of the said biography was a portrait of Copernicus (engraved by Jacob van Meurs), presented rather at random, vaguely following T. Stimmer's portrait (drawn at Strassbourg).

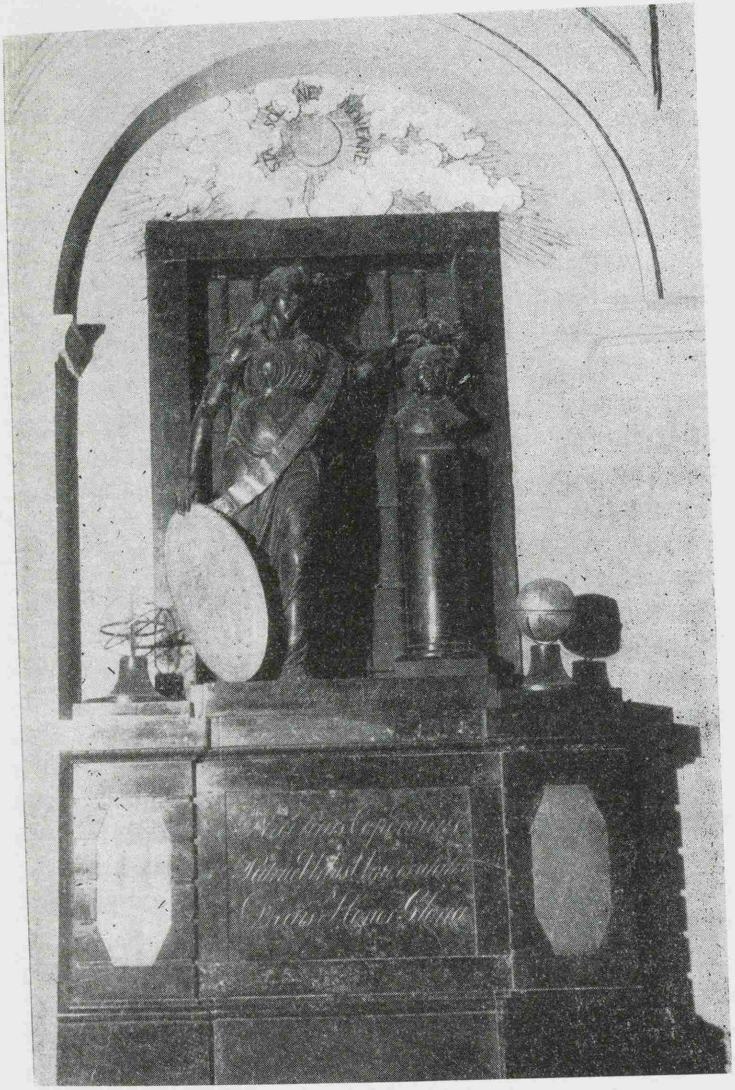


Jan Śniadecki, professor of mathematics and astronomy. Portrait painted by Alfred Römer. *Property of Jagellonian University Museum*

Przybylski had the portrait characteristically superscribed (in capital letters): "Nicolaus Nicolai Copernicus Thoruniensis Artium et Medecinae in Universitate Cracoviensi Doctor Canonicus Varmiensis Disciplinae Astronomicae in Europa Instaurator Natus Anno 1473 Die Febr. 19 Obiit An. 1543 Die Mai 24."

In the meantime the fame of Copernicus as a national hero was disseminating in Poland, at the Court of King Stanisław Augustus, in Varmia and in Toruń. A new portrait was painted in oil (acquired by the University Museum about twenty years ago). This is a version of the so-called Gołuchów portrait from which King Stanisław Augustus had a copy drawn for the Royal Society in London (1776). The portrait of Cracow is of the same type as the latter and there are good grounds to suppose that both portraits had been modelled on the astronomer's self-portrait, which in the sixteenth century was the property of his friend Tiedeman Gize, Bishop of Chełm (Gdańsk). Gize's portrait was to serve as model for the effigy of the astronomer on the clock at Strassbourg. The copy which is in Cracow (probably dating back to the early years of the seventeenth cent.) is a valuable addition to Copernican iconography.

The catastrophe of the partitions of Poland did not stop the spread of the cult attached to the name of Copernicus as a Pole and an alumnius of the University of Cracow. On the contrary, it grew more intense, especially since the moment when Śniadecki (1801) wrote a biography of Copernicus in Cracow for a competition organized by the Warsaw Scientific Society, and when Tadeusz Czacki went with M. Malski (1802) on a scholarly mission to Frombork in Varmia. In later years, at the times of the Duchy of Warsaw, the Coper-



Monument to Copernicus in St. Ann's Church in Cracow, after a Design by Sebastian Sierakowski (1822)

nican cult manifested itself by a public subscription to collect money for his monument, first at Toruń and then in Warsaw, where eventually (1830) a monument after a design by Thorwaldsen was to be raised.

At the time when the Committee for National Education was organizing and controlling scholarly activities in Poland, the Copernican teaching came to be universally accepted, "not from national pride, but for the love of truth", to cite the words of the Piarist Antoni Wiszniewski.

The Copernican cult at the University was again stimulated by Jan Śniadecki, who was Kołłątaj's friend and closest collaborator. At a public inauguratory meeting at the University Śniadecki delivered a speech, "An Eulogy to Nicolas Copernicus, an undergraduate of Cracow, reviver of astronomy, on the occasion of the opening of a chair in astronomy". The speech was very significant not only because Śniadecki opposed himself to the antiquated views about Copernicus and his theory, but also because he had sought out the sources, by the same pointing out to the MSS. kept at the University. This is what Śniadecki wrote to Kołłątaj about his own lecture: "...for five quarters of an hour I have been reading my [speech about] Copernicus, which was received with immense enthusiasm...; all this has come out so nicely that it is bound to enhance the reputation of the Academy in public opinion".

It can be generally stated that the main ideas then expressed by Śniadecki have traced the trend of research on questions relating to Copernicus up to our times, to the works of I. Polkowski, L. A. Birkenmajer in the nineteenth century and their present followers (H. Barycz, A. Birkenmajer, T. Przypkowski).

The veneration for the astronomer and his work at Cracow University was growing all the time. One of its manifestations was Sebastian Sierakowski's foundation (established in 1822). Earlier still, the renowned Latin poet Canon Mateusz Dubiecki had an alabaster bas-relief with an effigy of Copernicus built in amongst other plates and effigies of eminent men in the wall of his garden upon the Vistula (whose bed was running differently at that time, the spot being roughly located at the present corner of Dietla and Stradom Streets).

The astronomer's statue in the academic (St. Ann's) Church in Cracow built on Priest Sierakowski's allocation, is hardly an artistic success. Casimir Elias Galli, a Cracow sculptor, aided by the local brazier and engraver Antoni Arkusiński made the figures and ornaments after the founder's own design. On the monument Urania, the muse of astronomy, is crowning Copernicus' head with a wreath. The socle was cut out in black marble coming from Dębnik. The monument was placed at the end of the left aisle, taking up much room. Admittedly, there were no other sculptors in the town who would have made a better work. But the point lay elsewhere.

"It belongs to national fame, to revive the memory of our eminent men..." this is how popular review ("Pszczółka Krakowska") commented on 1 st June 1823 on the monument raised to Copernicus, at the same time explaining its patriotic significance. The fact that it was placed in the academic church was to prove that the Church was no more opposed to the Copernican teaching. The coats-of-arms of Cracow and the University, of King John Sobieski and the Ciołek-Poniatowski on Urania's shield, the legend: "Nicolaus Copernicus

Armillary Sphere — Planetarium, made by Józef Jüttner (1828).
Property of Jagellonian University Museum

Patriae, Urbis, Universitatis Decus, Honor, Gloria" — strongly emphasized the ties binding Copernicus with Cracow, and by the same the Polish character of the astronomer, an issue contested by German nationalism.

The armillary, i.e. the circular sphere is representing our planetary system by means of bands and circles. At the Jagellonian University Museum there is a sphere (a kind of planetarium) constructed by Józef Jüttner in 1828, after the heliocentric model of the Universe as expounded by Copernicus. Jüttner was a geographer, and a colonel of the Austrian army at Prague. He produced several models of this type, still nowadays held in high esteem by the specialists.

Another model of the Copernican system is represented by the armillary sphere with planets, probably a French model from the mid-nineteenth century for school use.

The third, wooden, model of the planetary system comes equally from the mid-nineteenth century, and on our view was constructed at the astronomical observatory in Cracow.

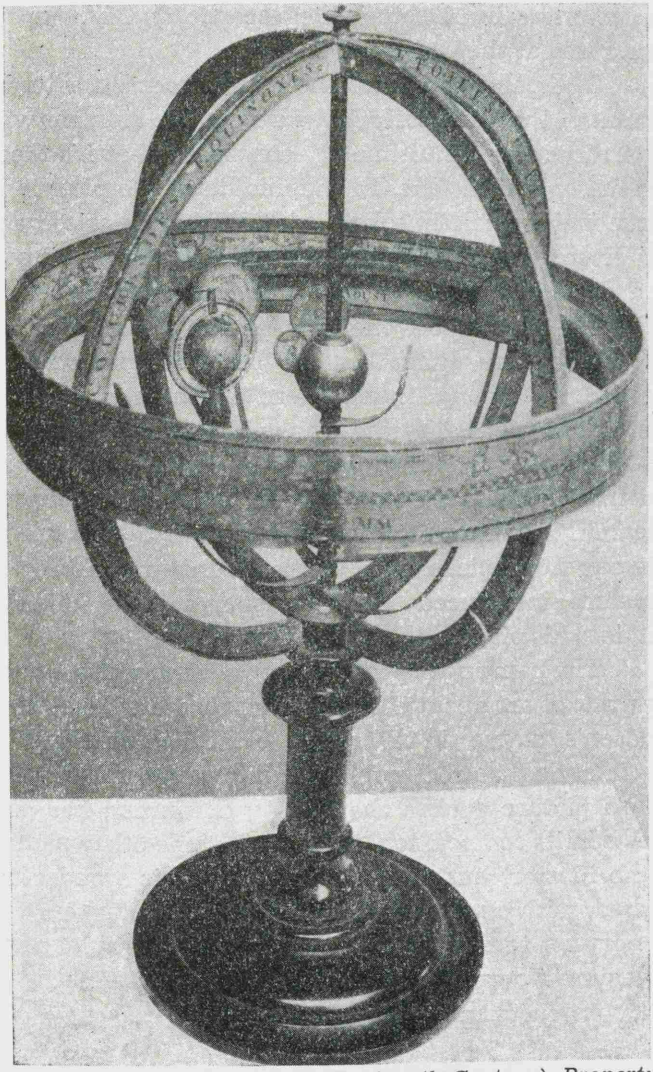
VI

The most valuable work of art related to Copernicus was to be bestowed on Cracow in 1873, the fourth centenary of the astronomer's birth. Despite the partitions, all Poland was united in the Copernican celebrations. This was a strenuous time, when under Bismarck's rule Great Poland and Pomerania were going through an intense process of Germanization. Cracow was the main centre in which the celebrations were held, radiating all over Poland.

At the astronomer's birthplace, in Toruń, two conferences were organized: one was official, German, with a strong support from Berlin; the second was Polish, and had to face considerable difficulties.

It was at that time, too, that Cracow acquired new Copernican relics, once collected by Princess Isabella Czartoryska and exhibited at Puławy. In the early seventies the Czartoryski collection was brought from the Hotel Lambert in Paris to Cracow, and with it the urn containing the ashes of the astronomer, collected at Frombork, his letters and records, and a collection of drawings with his portraits. In the vestibule of the Academy of Science on an allocation by Count Alfred Potocki a new statue was raised, the work of the sculptor W. Gadomski.

Also in the eighteen seventies (1872) the great Polish painter Jan Matejko started working on a big picture which was to show the astronomer at the moment of his discovery. During the celebrations the picture became in Cracow the main focus round which all the attention was centred. It gained general applause, and bids were made to the Master by various agents who tried to purchase the picture for the German collections. But the painter refused. Then a committee was established in Cracow with Piotr Moszyński at its head, and a public subscription was started to collect the necessary funds; once bought, the painting was offered to the University. It was placed in the library hall at Collegium Maius for the time being, but its destination was for the new University House. And so it happened: in 1886, on the painter's own advice, the painting was hung in the aula (main hall) at Collegium Novum. It was under this picture that the ceremony of conferring



French Armillary Sphere (Mid-Nineteenth Century). *Property of Jagellonian University Museum*

the honoris causa Doctor's Degree on Jan Matejko was solemnized at the University.

The painting shows the astronomer on a terrace in front of the Frombork Cathedral, at the moment when Copernicus became ultimately convinced that his theory was the only right one. In the middle of the picture the astronomer is half-kneeling with his hands raised as if in a gesture of religious ecstasy. Against the background of a dark starry sky stands outlined the Frombork Cathedral, farther off one can see the Baltic coast. On the terrace are lying several scattered instruments, a telescope among them. Here Matejko consciously altered historic reality: he was well aware, indeed, that the telescope was been unknown in Copernicus' lifetime and that Galileus was the first to use it for astronomic research. Yet he wanted to bring to light the connection between Copernican and Galilean investigations, and therefore introduced the telescope, against historical fact, into his picture.

The painting is probably so far the most outstanding work of art about the great astronomer. True, Thorwaldsen's statue in Warsaw, carefully arranged in classic style, has real nobility. On the other hand, Matejko's picture evokes the feeling of unrest, has some defects in its composition, just like in some other pictures of the Master, but at the same time it is wonderfully painted, with a sure hand. It infects the onlookers with its nervous tension. Hung high up in the aula of the Collegium Novum, it supplies the crowning effect to the hall, constructed and arranged in 1886.

VII

During the closing years of the nineteenth century an idea was maturing at the University, taking shape little by little: to commemorate the fifth centenary of the 1400 revival of the college in a particularly solemn manner, so that its name might become known all over the world. This was a reaction to the repressive measures which had been taken by the Austrian occupiers in 1864 to suppress the ceremonies in honour of the University's fifth centenary. Now one of the focal points in the celebrations became the act of unveiling the monument to Copernicus raised in the Collegium Maius courtyard. It was made to order by the sculptor Cyprian Godebski, who had been the author of several other monuments in Poland, among others, the Adam Mickiewicz statue in Warsaw.

In fact, the Copernican monument was placed in the courtyard of Collegium Maius, but the idea did not prove a lucky one altogether. The statue made of bronze stood on a heavy granite socle and represented the figure of a young student holding a globe in his hand, wearing, after the seventeenth-century fashion, a Polish nobleman's national costume or overcoat and knee-boots. The rather unfortunate idea of the student's right foot being pushed forward cannot be adequately accounted for. Godebski was a good sculptor, and certainly the separate parts of the monument were finely done — yet placed in the courtyard of Collegium Maius, it failed to produce the desirable effect. Moreover, the monument was placed on the site of the former well, deturning the atten-

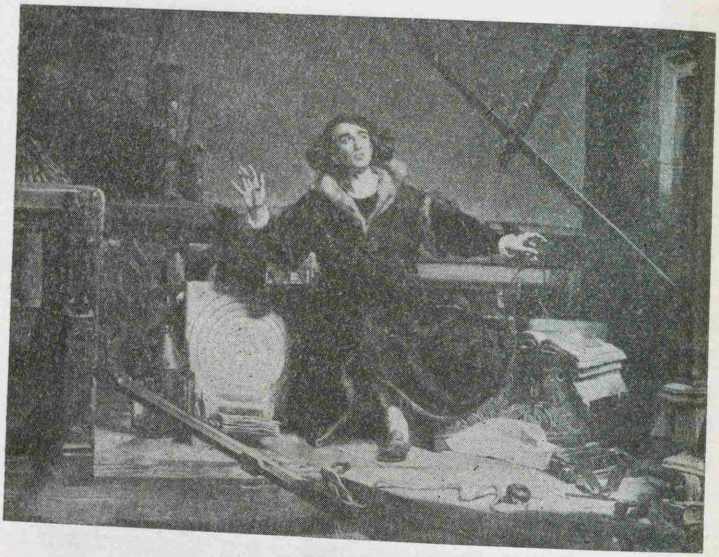
Statue of Copernicus in the House of the Polish Academy of Sciences in Cracow, sculpture by Walery Gadomski (1872)

tion of the visitors from the architecture of the courtyard. Thus directly after the monument was erected it met with strong opponents among the artists (L. Puszet) and finally in 1952, when the Collegium Maius was submitted to a thorough restoration and reconstruction, the statue was moved to the "Planty" park and placed near the Historical College of today.

In the years 1900 to 1928 an important work was done in the field of Copernican research, by the historian (of science in general, and of astronomy in particular) Ludwik A. Birkenmajer. He collected an enormous number of detailed, and even apparently trifling data, but which constitute a highly precious source material to the astronomer's life, incontestable testimonies of his ties with Poland — and with Cracow in particular. Later on his work was taken up by his son Aleksander Birkenmajer.

The fourth centenary of Copernicus' death (1943) could not be marked down because of the Second World War; but the 410-th anniversary was solemnly celebrated in 1953, and an exhibition was organized at Collegium Maius. Thanks to it, the restoration works were completed with greater speed; it permitted, too, to collect a number of valuable relics scattered in various places in the town, astronomical instruments above all. They were put on show in a separate room adjoining the aula in Collegium Maius, and have remained there from then on.

It should be put to the credit of the Polish Astronomical Society that the University Museum has acquired (1955) three precious Copernican instruments, reconstructed by Tadeusz Przypkowski, namely: an armillary sphere, a triquetrum. and a quadrant. The



Nicholas Copernicus at Frombork. Painting by Jan Matejko (1873.) *Property of Jagellonian University Museum*

first of these (the armillary sphere), composed of six circles, permits to calculate the ecliptic stellar co-ordinates. The triquetrum is an instrument consisting of three wooden bands. Looking through the sight vanes directed to the given celestial body, its altitude angle could be gauged. The third instrument was the quadrant, i.e., a sector of a circle with an angular scale vertically denoted. The quadrant was used to gauge directions; with its aid, Copernicus was calculating the solar and lunar altitudes. These instruments were probably constructed either by Copernicus himself or else they were made after his design, all in wood. They have been described at length by Tycho Brahe.

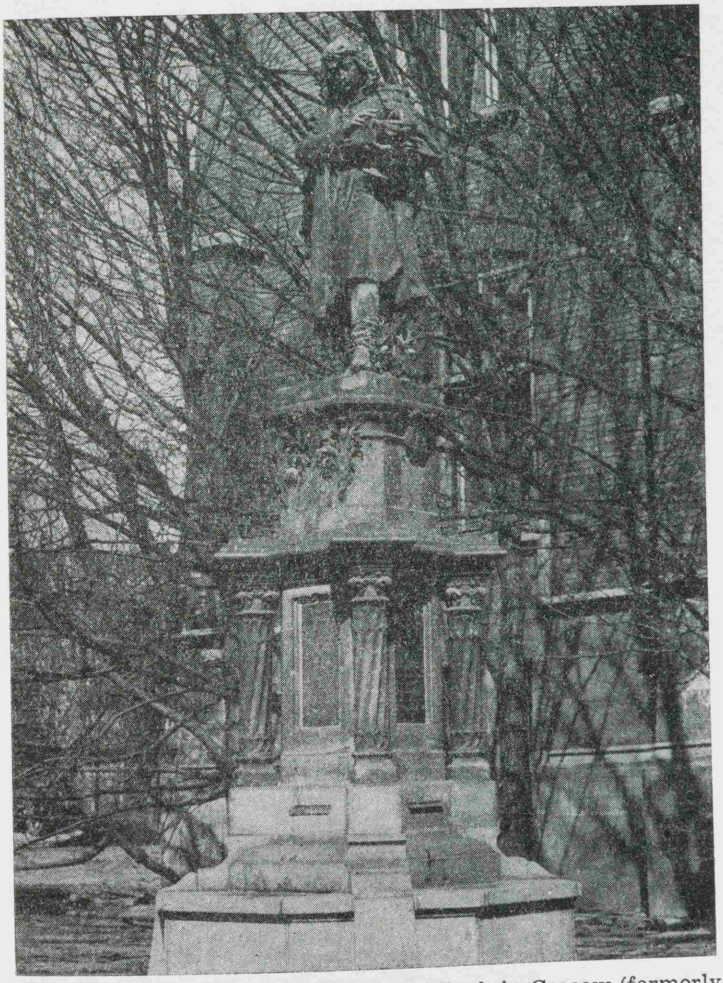
Since the sixteenth century up till present, Copernican memories have been always vivid at the University. The old city of Cracow which had seen the beginnings of the astronomer's academic career, has been one of the centres from which the Copernican cult was radiating all over Poland. A live testimony of the fact are the numerous relics preserved at the University.

A Bibliographical Notice

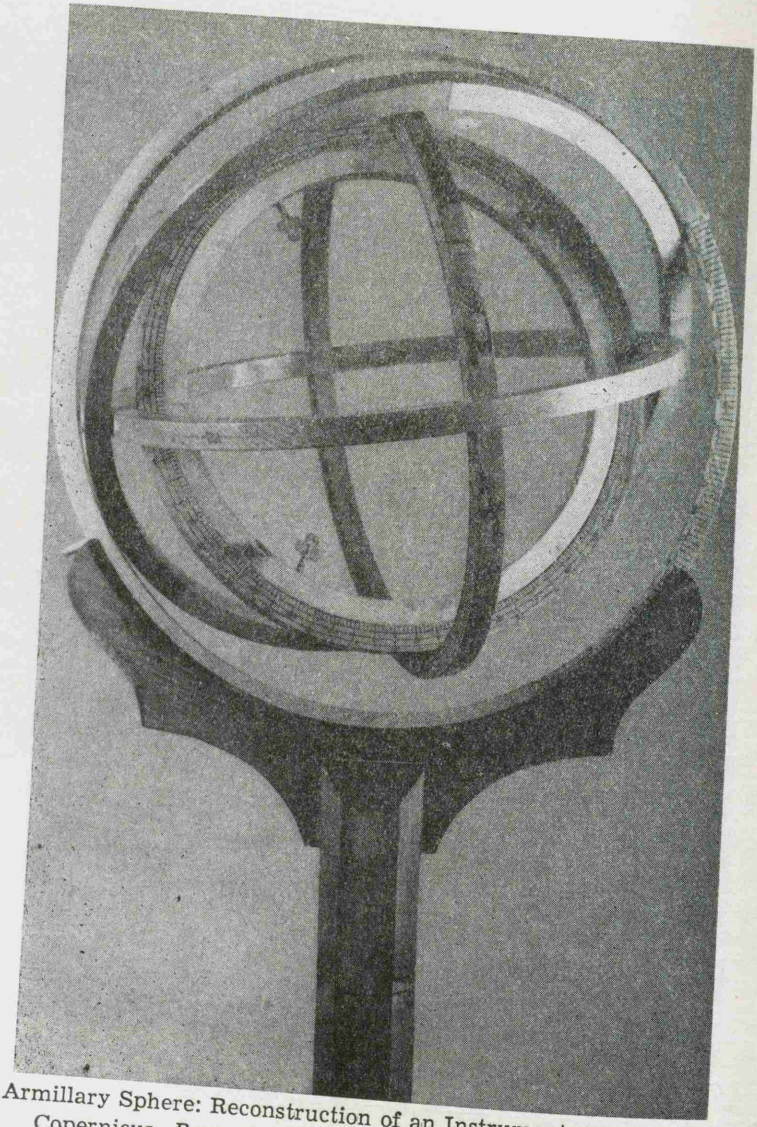
The Copernican literature comprises an outstandingly vast number of publications, and several bibliographies, listed in a fairly exhaustive way in Nowy Korbut II, 384.

Here mention should be made, above all, of the older Polish authors who wrote on the subject: J. Polkowski, Ludwik A. Birkenmajer, Z. Batowski. I have used also more recent works, by Z. Ameisenowa (*Globus Bylicy*, Kraków 1951), H. Barycz (especially his dissertation, *Kopernik w dziejach narodu i kultury polskiej*, Poznań 1954), T. Przypkowski (*Dzieje myśli Kopernikańskiej*, Warszawa 1954, and *Globus Bylicy*, „Kwartalnik Historii Nauki" 1961), J. Pagaczewski („Komunikaty Mazursko-Warmińskie" 1, 1964, and „Urania" 1963, No. 5).

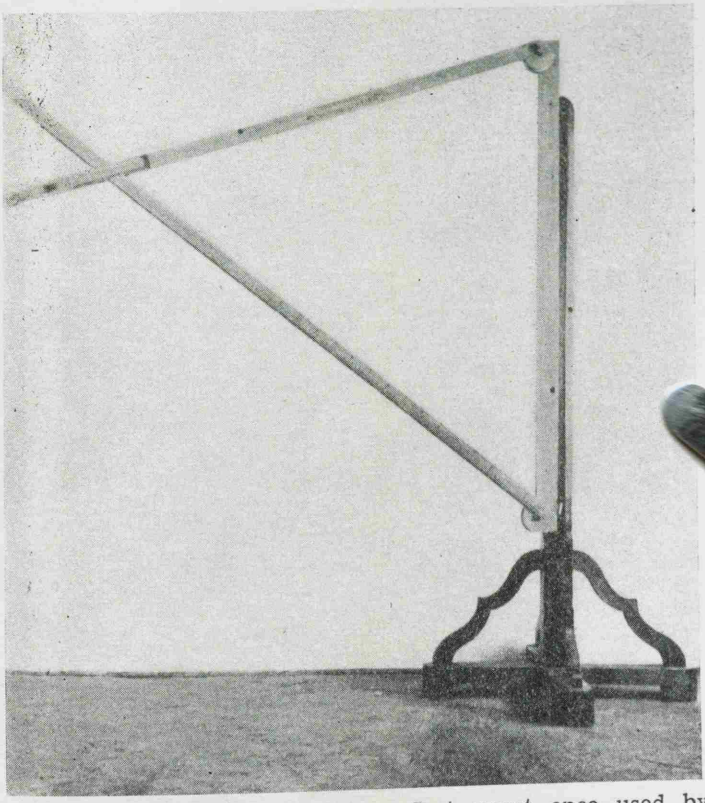
Of the works by foreign authors, mention should be made of the work by the eminent German historian of astronomy Ernst Zinner (*Astronomische Instrumente*, Münich 1967) who has discussed both Copernicus' instruments (p. 283) and those of Martin Bylica (p. 295). Regarded from the Polish point of view, Professor Zinner's work might be supplemented with many additional data.



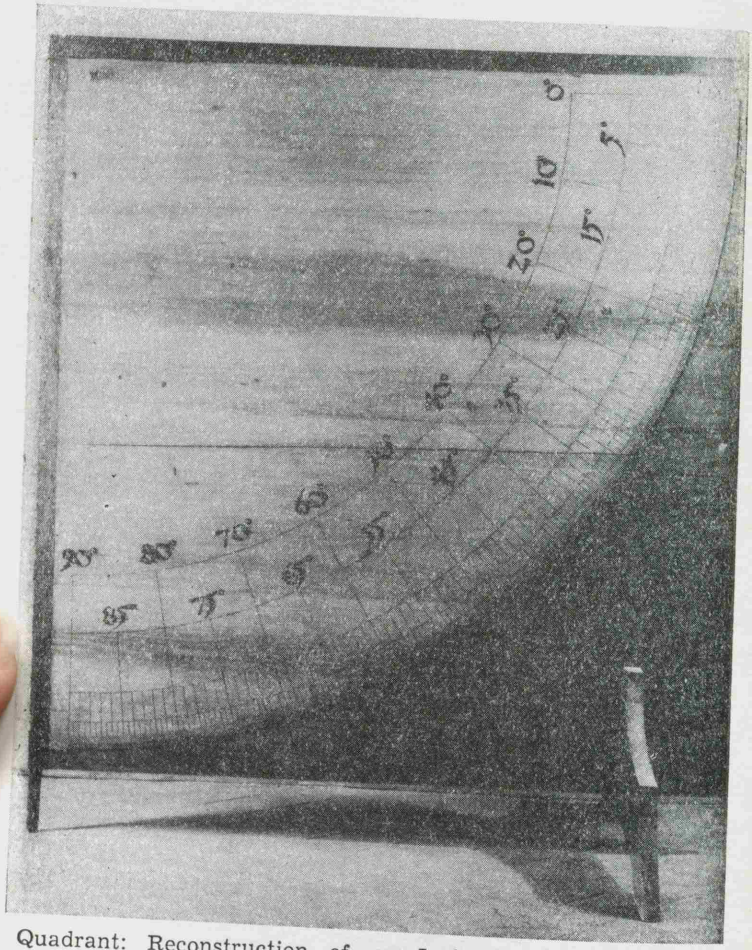
Copernican Monument in the „Planty" Park in Cracow (formerly in the Collegium Maius courtyard), by Cyprian Godebski



Armillary Sphere: Reconstruction of an Instrument once used by Copernicus. *Property of the Polish Astronomical Society*



Triquetrum: Reconstruction of an Instrument once used by Copernicus. *Property of the Polish Astronomical Society*



Quadrant: Reconstruction of an Instrument once used by Copernicus. *Property of the Polish Astronomical Society*

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COPERNICUS AND THE ASTRONOMICAL REVOLUTION

by

Gerhard H. Wolter
Professor of Physics

This address, the third in the annual Zinner Lecture Series, was delivered in the Sciences & Engineering Library on May 4, 1969, the seventy-second anniversary of the founding of California State University, San Diego.

COPERNICUS AND THE ASTRONOMICAL REVOLUTION

Man in the twentieth century is beset by a multitude of pressing problems. Almost all are of his own making. Desperately he struggles to find solutions yet he finds there are no ready made solutions. Embedded in such an array of problems in our time, we may ask whether we have the time to speak about Copernicus and his revolution. After all, Copernicus' revolution occurred some four hundred years ago. We have some important things to do right now, so why waste time? Besides, every educated person knows Copernicus made his discoveries without a telescope. He found that the earth moves around the sun, and perhaps, hesitantly, a few more bits of information emerge.

Should a thinking person take a stand against such an attitude? I feel he should. This is especially true in a time when there are still so many who are profoundly igno-

rant of our cultural past and its traditions.

For my third annual Zinner Lecture I have chosen Copernicus as a topic because it is evident from the Copernicus bibliography, prepared by San Diego State's Sciences Library to coincide with this lecture, that San Diego State College has an impressive collection of works on Copernicus. Many are part of the Zinner Collection of books and documents on the history of science and astronomy. I have chosen Copernicus for another reason, too. Copernicus worked more than thirty years to bring his book to perfection. After lifelong efforts he was still not happy with his own results. Thus we may ask, "Was he a man dreaming about a permanent revolution?" The answer is no. Copernicus was a quiet and a pious man. He was neither a Napoleonic conqueror nor a Caesar. Nevertheless he conquered an empire. No human had ever dared dream of an empire so great. Copernicus was the first man who dared step into infinity. Not in a philosophical sense--this had been done by others before him. Instead, he expanded the cosmos, the universe.

Copernicus singlehandedly defied the learned men at the universities of his time. He defied a powerful Church and the teachings

of Aristotle and Ptolemy. He did so without expecting any rewards. In fact he was quite aware his contemporaries considered him a fool at best, that others called his ideas absurd, and that Philip Melanchthon, the great Preceptor Germaniae, tried to invoke the law against him to remove his spiritual license. Copernicus began his revolution more than four hundred years ago. We are still experiencing it. Last December when our astronauts were swinging around the moon, and later when they were heading home towards our good old planet earth, human eyes saw for the first time what Copernicus had seen in his mind before. This was one of the great triumphs of the Copernican Doctrine. The astronuats experienced the great void, the emptiness of space he had envisioned replacing the spheres of Aristotle.

Goethe, the German poet, wrote about Copernicus, "Yet of all discoveries and convictions nothing might have created a greater effect upon the human spirit than the doctrine of Copernicus. No sooner had the world been recognized as round and in itself complete than it was asked to waive the privilege of being the center of the universe. Perhaps a greater demand has never been made on mankind. What all dissolved into mist and smoke by this recognition? A second Para-

dise? A world of innocence? Poetry and piety? The testimony of the senses? The conviction of a poetic-religious creed? It is no wonder people did not want to let all this go. No wonder they opposed such a doctrine in every way--a doctrine which entitled and invited those who adopted it to a hitherto unknown, indeed unimagined, freedom thought and greatness of mind."[1]

Copernicus' astronomical revolution was the beginning of a process which has not ended yet. We are still in the midst of it. The burning fire of his revolution is a slow burning fire.

In his lifetime Copernicus had only a few friends. There were a few in Germany, a few in Poland, some in Rome. With the exception of these few no one else was particularly interested to claim him or to recognize his greatness. A hundred years after his death the simple memorial plate that had been embedded upon his grave was removed. It carried nothing but his name and his birth and death dates. Why was it removed? We do not know for sure, but obviously there was no outcry, no indignation at the removal. Copernicus' book was on the Index, and people were afraid to admit they owned a copy of it.

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[1]Goethes Werke, 3d ed. (Hamburg, 1966), XIV, p. 81.

In 1807 Napoleon visited the house in Torun where Copernicus had been born. He expressed great surprise that the astronomer's fellow citizens had not erected a shrine or a suitable monument in his honor. The fact was that Copernicus was not yet considered a great man.

Four hundred years after Copernicus' death two nations quarreled about the right to claim him as a great son. The Germans claimed him because of his German name, Niklas Koppernigk, and because of his ancestry. The Polish nation claimed him proudly because he was born in a town considered to be in Poland at the time he was born. San Diego State's Zinner Collection has available detailed documentary information for anyone interested in studying this specific part of his life.

I personally prefer to look on Copernicus as the first man who saw the universe consciously, not figuratively or in a philosophical sense. He did not step into this universe by accident. He toiled and labored thirty years to bring his theory to perfection. It is worth pointing out that such an attitude was common and respected among men of science and philosophy at his time, and even later Educated men restrained themselves for

many years before publishing their new discoveries. This is in contrast to the present publish or perish syndrome. Small bits of information were not called a breakthrough. Copernicus is a shining example of a man who tried hard to disprove, to destroy, his own calculations. He published his work only after he had examined exhaustively every possible consideration that might refute his theory.

The idea of de-emphasizing personal involvement with a subject of one's own creation is not just a rational process. We should understand that we are all involved with our work and are part of the creative process. It is customary to picture scientists as cool-headed and rational beings who reject any, or at least most, emotional factors. But we should ask the important question, how can anyone spend years calculating something so intangible, so esoteric, as Copernicus did, especially since there were no financial rewards, not even fame. Only a man very strongly motivated and driven by unusual emotional factors will continue the pursuit of the elusive goal of his faith, a faith not shared by others. Copernicus had that faith.

Niklas Koppernigk, Better known under

his Latinized name Nicolaus Copernicus, was born on February 19, 1473. He passed away on May 24, 1543. To understand Copernicus and his work one has to understand his time, the teachings of Aristotle and all those activities known to us under the name of Scholasticism, the combination of Greek philosophy with the Mosaic Law. Scholasticism was a set of criteria under which mediaeval philosophy and dogmatic religion enabled man to judge himself and the universe. To the scholastics Aristotle, the tutor and teacher of Alexander the Great, was a philosopher who had given foundation to rational thinking. He conceived of a universe centered not only on earth, but also on man, the supreme achievement of creation. This particular view of man as the supreme achievement of creation was almost the preoccupation of mediaeval scholars. Furthermore, Aristotle had believed the earth was at the center of the heavenly spheres which revolved around it with perfect movement. The outermost sphere was the limit to the universe and to this sphere the fixed stars were attached. All inner spheres were transparent. Light could pass through. These spheres were guiding the planets, the sun and the moon. To account for all movements observed since the days of Babylon and the Egyptians, Aristotle

had assumed fifty-five spheres.

There was little in this simple and beautiful universe in conflict with the teachings of the Church. The universe was finite and complete, just as described in Genesis. It was the record of how God had created the world in six days. To these fifty-five spheres more refinements had to be added gradually, all based on observations. Earlier records have been lost, but Ptolemy had assembled everything known in his days in his authoritative text the Almagest, a compilation of astronomical knowledge which remained the foundation of astronomy until 1543, the year Copernicus passed away. It was also the year his doctrine was published. For centuries Aristotle had been considered the ultimate authority on human thought. His monistic approach to all knowledge appealed to Arabic and Christian scholars alike. Many Greek and Latin texts were studied at the European universities in Copernicus' time which claimed all science and all religion must be dominated by one single theory. This belief was so strong that the Church felt compelled to tell people how they should live, how they should think, and what was proper to believe about nature and about nature's ways. Copernicus was born at the very time the Church

began waging war against unorthodox thinking.

The art of printing with movable type resulted in the dissemination of ideas throughout Europe with astounding swiftness. As long as books had to be copied by hand, each was a true manuscript. The number of copies was limited. The manuscript books belonged to monasteries and libraries. A few individuals had some. The Church had records of who had copies. To copy a manuscript by hand took a month. It was impossible to hide the fact a book was being copied. The number of competent scholars in all Europe was perhaps less than a hundred. The Church knew also who studied a particular text, since these scholars knew each other. This easy control of books changed radically when printed texts became available by the hundreds and even thousands from one single printing. Copies of forbidden works began to change hands underground. Moreover, the spread of the art of printing to many places in Europe made it almost impossible to control where these books went. It should be noted, too, that the discoveries of Vasco da Gama had brought new life blood into stale thinking patterns. There was excitement in the air. The discovery of America brought still more

excitement. Ulrich von Hutten exclaimed: "O Century! O Sciences! What a Joy to live!" He was not alone. In universities students were striving after truth, minds were stirring.

At this same time the Church had become the largest landholder in Europe. Bequeathing a few acres to the Church would bring assurance to frightened souls. A larger land donation would bring more heavenly peace to the donor. Small donations here and there had grown into large territories. Pressures were exerted against landholders surrounded by church property. For the sake of peace they donated, too. Thus, the Church had become more powerful than many governments. With this growth pattern the Church also assumed the privilege of persecuting ideas, new ideas which were endangering the establishment and its sacred teachings.

At the age of eighteen Copernicus entered the old University of Cracow. Founded in 1364, remodeled in 1400 after the model of the still older University of Prague, this seat of higher learning excelled in mathematics and geometry. In his studium generale Copernicus found himself exposed to the great and liberal teacher, Albert Brudzewski, who

introduced his students to Aristotelian thought. He inspired the young Copernicus to take up the study of astronomy, the study of the Almagest. It is very probable that he was introduced here also to the tables of Peurbach and Regiomontanus. The latter had died in Rome just sixteen years earlier, leaving behind an unfinished calendar reform. The fame of Regiomontanus and his teacher Peurbach had spread to all universities in Europe. Many young men wanted to be as famous as they were.

Study of the Almagest made Copernicus aware that the fifty-five spheres had been expanded into an array of eighty. Yet, observations showed the stars were not in the places the tables predicted them to be. Thus gradually more assumptions had been added to account for the observed positions. One assumption was that the sun, moon, and the planets were not moving with uniform speed, despite the claim of Aristotle that such movement was perfect. Later on when additional deviation became obvious, another assumption was that each heavenly body had a different particular path, and that their respective centers were not identical with the earth's. Even then the planets did not move as the tables predicted. Especially bother-

some were the retrograde motions of the planets. To explain such strange motions another astronomer invented epicyles. There was an assumption that each planet rotated in a secondary circle attached to the primary circle or orbit. By 1400 it was obvious once more the tables contained errors. Peurbach and Regiomontanus had recalculated the tables of Ptolemy. But the equinox, the time when the apparent movement of the sun crosses the celestial equator, was wrong. This crossing had been a time of pagan festivals since time immemorial. Christianity had placed the celebration of Easter at the spring equinox. The prediction of the correct date for such an important celebration, the celebration of Christ's resurrection, was based on the tables of Ptolemy which were extremely out of synchronization with the actual movement of the heavenly bodies. It was disturbing to the faithful. Calendar reform was a continuing worry. Peurbach and Regiomontanus had worked at it, but both died young. Two decades after their deaths calendar reform was still not accomplished. The demand for a new calendar remained.

When did Copernicus receive his revolutionary ideas? The answer is not clear. Perhaps it was during his second year at

the University of Cracow in 1492, the year Columbus made his famous discovery. Dissatisfied with the cosmic order described in Aristotle's and Ptolemy's work, his revolution started in the mind, in patterns of doubt.

Copernicus' studies were interrupted briefly when his maternal uncle called him home to be seated as a canon in the cathedral of Frauenburg. His uncle, Varmiensis, Bishop of Ermland, had the power to appoint new canons whenever vacancies occurred. When Copernicus came home an immediate position was not open. He was presented to the chapter, however. His uncle then recommended he go to Italy to study Canon Law, a useful undertaking for anyone preparing to enter the Church hierarchy. In 1496 Copernicus left home for Italy, matriculating in January, 1497 at the University of Bologna. For three and a half years he studied law, philosophy and Greek. The latter subject was studied with vigor. It should not be a surprise to learn that he was also attracted to an astronomy teacher, Domenico Maria Novara, who had once been a student of Regiomontanus. Novara was professor of mathematics and astronomy who openly admitted he was a Pythagorean. He courageously taught that something was wrong with the

complexities of the Ptolemaic system. He encouraged his students to read Hicetas, a Greek philosopher of about 500 B. C. who believed the earth revolved on its axis. Another Greek, Aristarchus, about 250 B. C., had the same idea, but also believed the great fire, the sun, was at the center of the universe. This was highly unorthodox teaching and was in direct contradiction to Aristotelian ideas.

Copernicus found, too, that Heracleides of Pontus and the Pythagorean Philolaus had believed the earth moved around the great fire. Such ideas were not found in Aristotle. His searching mind had seen the inconsistencies in the Ptolemaic universe already while he was a student in Cracow. Thus, Copernicus began to wonder once more whether such absurd ideas as offered here might not contain some truth. While being exposed to the teachings of Domenico Maria Novara, Copernicus learned the skills of observation and the use of instruments in such observation. Copernicus' skills were put to the test in March 1497 when the occulation of Aldebaran, the bright star in the constellation Hyades, took place. We still have records of this event--a turning point in the life of Copernicus. The moon in its path across the sky

sometimes gets in front of a star. A star occultation occurs. In this case the bright star Aldebaran suddenly dissappeared behind the disk of the moon. After a period of some anxious waiting, it reappeared, coming out on the other side of the moon. Copernicus described this event in his book, De Revolutionibus.[2]

Star occultation is a remarkable sight. Since the moon has no atmosphere the dissappearance is quite sudden. Its reappearance is equally impressive with its extreme suddeness. Anyone who has witnessed one of these rare occultations perceives an awareness of order in the universe. The observer can calculate in advance when it will happen, because the moon approaches the star with uniform speed. Knowing this speed one can also calculate in advance at what time it should become visible again. Imagine Copernicus' thrill when all this happened--when everything went as calculated! To him this event became the highway to the infinite universe. He began to doubt the validity of the Aristotelian spheres.

There were dark clouds on the horizon, warning signs of a brewing storm to come. Savonarola and two of his monks were hang-

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[2]pp. 128-29

ed in public in Florence. Their bodies were burnt and their remains thrown into the Arno River. Savonarola had expressed heretical views. He was a purist and a reformer. He had preached in Bologna and he preached in Florence. In his sermons he lashed out against the luxurious life. Many people wept bitterly, feeling the guilt of their sins. The Curia made several attempts to pacify this unruly monk. He was promoted from a simple convent gardener to the elected prior of the monastery of St. Mark in Florence. That was the same year Copernicus had entered the University of Cracow, the same year Erasmus of Rotterdam entered the monastery in Utrecht.

Two years later, 1493, Savonarola was promoted to Vicar-General of Tuscany, a very high honor. When he preached, the great cathedral of Florence could not hold the crowds. After his very emotional sermons ladies gave up their jewelry and money lenders even contributed sacks of gold. Savonarola lashed out ferociously against corruption in high places in Italy. On Christmas day, 1496, the year Copernicus came to Bologna, Savonarola led 1500 children, all in white, in a great procession to the market place to receive Holy Communion there. The

Church frowned, calling this performance a festival of higher madness. He was warned he could no longer preach in public. Yet he continued. He was warned again and it was hinted a few thousand ducats given to a certain place in Rome might influence some of his critics favorably. He could have raised the sum easily using one or two of his sermons. He stubbornly refused. In May 1497, Pope Alexander VI, also known under the name Cesare Borgia, laid the Great Ban on Savonarola. Two months before this event Copernicus had observed the occulation of Aldebaran. Savonarola was excommunicated and executed in May, 1498 for daring to dispute the teachings of an all-powerful Church.

In West Prussia in the meantime an old canon had died. The vacancy in the Cathedral of Frauenburg was filled by Copernicus. He had to hurry back from Bologna for his election and seating as a canon. He asked immediately after the election, however, for a leave of absence to finish his studies. Permission was granted and he returned to Italy. When he arrived he learned about Savonarola's fate. There cannot be any doubt Copernicus understood the dangers of being a heretic.

In Bologna the young scientist observed a conjunction between the planet Saturn and the moon. In the same town a man named Giorgio di Novara was burned alive in the market place because he had expressed free thoughts on many occasions and was foolish enough to make such remarks at the wrong place. We do not know whether Copernicus witnessed this burning, but since he was in Bologna he must have been informed about the happening. The year 1500 was by papal decree the Year of the Great Jubilee. In April 1500 Copernicus left Bologna for Rome to participate in the Easter celebration. Traveling to Rome Copernicus had time to contemplate the consequences of heretical views. His views of Ptolemy and Aristotle were definitely heretical in the eyes of the Church. In Rome he delivered a well-attended lecture on mathematics where he was consequently introduced to some dignitaries at various meetings. Among them were a few who had listened three decades before to the famous discourses of Regiomontanus who died in Rome in 1476.

In July 1501 Copernicus appeared before the canons of Frauenburg to report on the progress of his studies. Since he had not finished them, and since he had not taken any

examinations yet, he had to ask for another extension of time. He promised to study medicine, besides law, convincing the good canons that the presence of a competent physician in Frauenburg would be useful, not only to the chapter of the canons, but also to the poor. Two more years of study were granted for this purpose. We do not know how he convinced the canons that practicing astronomy was actually part of his curriculum, but apparently he was successful in convincing them that a good physician had to be the link between the stars and the patient, and that his knowledge of stars was vital to the health of the patients. This may sound silly, but actually in those times most physicians administered medicine according to planetary positions. Astrological nonsense was in great demand, and most honest astronomers did not have much of a choice. To make a living they had to be either a charlatan or an astrologer, or both. Even the religious leaders in Rome considered astrology part of intellectual knowledge. To cast a horoscope was considered an honest intellectual exercise, just as good as an interpretation of a learned text. Astrology belonged to the realm of metaphysics and Aristotle had devoted a whole chapter to metaphysics.

We should note that even a hundred years after Copernicus astrology was still considered an honest enterprise--the supreme intellectual challenge of the human mind. Kepler wrote in his treatise on the stargazing superstition. "This astrology may be a foolish damsel, but Dear Lord, what would become of her mother, the highly sensitive Astronomy, if she did not have this foolish daughter. After all the world is a good deal more foolish. . ."

To understand Copernicus and his revolution it is necessary to understand his century. It was a Janus-faced century. We have the time of the great humanists but also the time of the Inquistion. Charlatans and astrologers wrestled with calendar reform, but astronomers were concerned with new scientific knowledge. The transmutation of metals into gold was seriously attempted by very honest men in search of the philosopher's stone. Do we all realize that the same Newton, the great Newton, who pondered gravity, wrote pious sermons for many years and searched for the secrets of the philosopher's stone, or some other secret connected to it? In London there was a United Company of Barber Surgeons, and Vesalius published his famous book, De Humani Corporis Fabrica

in 1543, the year Copernicus passed away.

We can do justice to Copernicus only if we understand the strange mixture of progress and superstition in his time. The bold innovator Copernicus who did away with a 2000-year old error, who overturned the geocentric view of life, the same Copernicus remained spellbound by the work of Ptolemy. He even dedicated efforts during his later life to a reconciliation of his revolutionary ideas with those of Ptolemy. His teacher, Domenico Maria Novara, whom he called Preceptor Domenicus, Peurbach and Regiomontanus, all wanted to save the Ptolemaic system by some means. Do we really understand his desire to save the model of Ptolemy? One has to grasp this aspect of his life before he can understand the heroic struggle Copernicus went through before he could sit down to write the revolutionary concepts of his doctrine.

All of us think along the same lines our predecessors did. We prefer to perform actions the same way others do. Only a few will attempt to extract in a systematic manner the things which are wrong, or will dwell on errors with the intent of finding their source. Copernicus did exactly this. He re-

ceived a sharp stimulus for further inquiry when he saw the shortcomings in the tables of Ptolemy. Others had seen these errors but they tried to patch them up. Copernicus went deeper. He experienced, too, the pain of confusion. In astronomy one needs time. The stars move slowly. At all times the astronomer had to be alert to new events not listed in the tables. Even if they were listed one would not know exactly at what time astronomical events actually would occur. This was particularly true because the tables were wrong by as much as a month or more. Thus Copernicus observed the sky with utmost care, concentrating on such rare events as eclipses, conjunctions, and occultations.

In 1507, after fourteen years of study, Copernicus left Italy returning to his home in Frauenburg. He had a doctoral degree in law and the right to practice medicine, too. Frauenburg was a small town with about 1500 people. His daily routines were simple. He had to listen to quarrels and complaints among neighbors, citizens, and peasants. He practiced medicine among the poor who worshiped him, adored him. He prepared drugs and ointments for the sick, attended meetings of the canons, and collected rents from peasants and citizens who farmed church

property. In short he lived a very ordinary life with very little excitement. Sometimes he had to travel because of distant calls on his services as a physician. He was called upon to give his opinion on how to stop inflation, and to advise in financial matters. He even had to defend the castle of Allenstein against hordes of unruly soldiers. This he did successfully, too.

Most of Copernicus' life was spent in Frauenburg. It is very fortunate his many activities were not really too demanding on his time. They produced little intellectual excitement, however. Thus he found ample time to dedicate to his true vocation--astronomy. For thirty-five years this quiet man observed and calculated, observed again and recalculated, his many observations. This significant work was carried out in a remote spot of the world which was not even a center of higher learning. Hesitating for many years to publish his work we see that he had become sensitive to the dangers of uttering wrong thoughts. He had seen the danger already during his student days, and he saw it happening in West Prussia. In Danzig and in nearby Elbing some people were hanged. Others were punished severely in other parts of Europe. Burning and hanging in the

market places was not uncommon at that time. Charges of witchcraft, of being a charlatan, or of having expressed heretical views, were made and convictions followed without much proof. Could Copernicus really say aloud what his innermost thoughts were? Could he claim without fear of punishment that the earth moved? Everything he wanted to say was against the teachings of the Church--against established rules. The Church did not tolerate imprudent statements.

Copernicus dedicated twenty-three years, the period 1507 to 1530, to the perfection and completion of his theory. His reluctance about publishing his doctrine remained strong. Some intimate friends knew about his theory. Bernhard Scultetus, a canon in Frauenburg, was probably the first to know, perhaps as early as 1515. We definitely know that the cardinal Nicolaus Schomberg of Capua, a cardinal residing in Rome, asked Copernicus in a letter for a copy of his work. About the same time rumors were circulating in Germany referring to a short publication known as the Commentariolus, published sometime between 1509 and 1514. It reportedly stated that a Polish astronomer had worked out some new system of planetary

movement. In a booklist compiled by a man named Miechow, there is an entry: "A manuscript of a theory of the planets, in which it is theorized that the earth moves and the sun remains at rest." Does this item refer to the Commentariolus? The answer is uncertain. The date of the entry is May, 1514. The reception of his preliminary publication seems to have been very cool. No enthusiastic notices are known.

Rhaeticus, Professor of Mathematics and Astronomy at the University of Wittenberg, was very interested to hear news about discoveries in astronomy. In 1539 he took a leave of absence to go to Frauenburg to learn from Copernicus himself more about his theories. Rhaeticus reported what he learned in a communication to Germany, to his friend Johann Schoener in Nuremberg. This communication is known to us as Narratio Prima. It is probable that this letter precipitated more rumors. At this very time there was a band of clowns traveling in West Prussia making fun of Copernicus. These clowns played their tasteless jokes in the market place of nearby Elbing and even in Frauenberg. The ridiculing performances were given to the applause of the masses.

Copernicus was sixty years old. Concerned friends asked him to do something about this disgrace, but he calmly said, "The masses do not understand my teachings, and what they enjoy, I do not care about."

Rhaeticus was a Protestant while Copernicus remained a faithful Catholic. Despite the controversial struggles between the two religions, the two men became friends. The younger Rhaeticus tried to persuade Copernicus to publish his discoveries but left Frauenburg without the manuscript.

Finally in 1542 another intimate friend of Copernicus, the very liberal and tolerant Tiedeman Giese, Bishop of Culm, was able to obtain the manuscript from Copernicus. Rushing the book to Rhaeticus the latter hurried to Nuremberg where he handed the precious manuscript to his friend Schoener. Rhaeticus brought together with the book a recommendation written by Melanchthon, the German Reformer who wanted to remove Copernicus' spiritual license only a few years earlier. Seeing the book he probably realized that acting on rumors is acting on matters beyond understanding. He must have felt ashamed when he saw the completed work which contained so much more than rumors

ever had conveyed.

In Nuremberg Schoener with the cooperation of the Lutheran Minister Osiander printed the first edition of Copernicus' book. Osiander left out, however, for some strange reason, the original preface written by Copernicus himself addressed to the Holy Father, the Pope. Osiander replaced the original preface with one of his own giving his introduction the title: De Hypothesibus Hujus Operis. Osiander wrote this addendum in such a manner as to lead the reader to believe Copernicus had written it. He also changed the title to, "De Revolutionibus Orbium Coelum." Actually Copernicus had said in his own preface just the opposite of what Osiander said. Copernicus said he had been afraid for a long time his work might arouse contradiction, and that he had given consent to publish it only after friends had pressed him continuously for years. Copernicus said, "I have kept this book not for nine years. I have kept it out of circulation for thirty-five years."

Fate can be at times very ironic. An advance copy from the first printing arrived in Frauenburg just in time that Copernicus might hold it on his deathbed. Almost blind

and paralyzed by a brain hemorrhage, his hands touched the volume, lovingly, before he died. There are those who claim he went into a rage on his deathbed when he learned about Osiander's preface, aggravating his poor condition, thus hastening his death.

Why did Copernicus wait so long to publish his discovery? Why did Osiander write his own version of the introduction? Were both men afraid of an intellectual hurricane to come? To me it is obvious that the publishers wanted to blunt the impact. Soon after the great astronomer's death Giordano Bruno made himself the spokesman of the Copernican Doctrine. He said in public that Osiander's preface could have been written only by an ignorant ass for the benefit of some other asses. The outspoken stand of Giordano Bruno did not last very long. Fifty-seven years after Copernicus died history wrote the year 1600. Giordano Bruno was burnt alive at the stake for his heresies. Osiander's preface did brake the onset of the storm, but when it came Copernicus was beyond reach of the hostile authorities.

Three years and seven months after the death of Copernicus,Tycho Brahe, the second great pioneer in astronomy, was born. On

August 17, 1563 a conjunction of Jupiter and Saturn occurred. At the age of seventeen Tycho Brahe made his first recorded observation of this event. Astrologers thought this conjunction had much significance. Brahe reports that the Alphonsine Tables were wrong by a whole month, the error in the Prussian tables, the tables based upon Copernicus' observations, was only a few days off. This discrepancy convinced Brahe that only more observation would solve the riddles of the universe. With tremendous labor Tycho Brahe produced a huge amount of observational data which became the property of his assistant Johann Kepler. It was Kepler who reduced the movement of the planets to three famous laws.

The direct consequences of the Copernican Doctrine were felt more and more as time went on. The slow burning fire of the revolution kept creeping further, but participation in that revolution became dangerous. Galileo was jailed and suffered in the dungeons of the Inquisition because of it. He was forced to recant declaring to the Court of the Inquisition, "I do not consider Copernicus' opinion to be true, and I have not considered it to be ture, since I was ordered to renounce it. For the rest, I am here in your

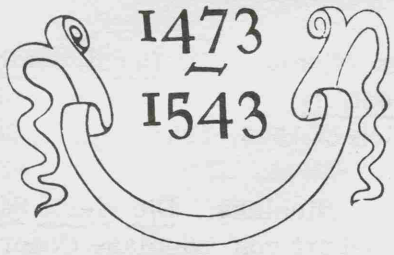
hands, do with me as you please."

Galileo fell silent. He remained silent for years. Giordano Bruno was dead. Campanella was imprisoned, Foscarini had been condemned. Servetus was burned at the stake. Even in 1794 the German philosopher Immanuel Kant was reprimanded for distorting several fundamental facts, fundamental to the doctrines of Holy Scripture and Christianity.

The Church at that time took the position that Christianity in its traditional form could not exist in an infinite universe. Rome did not want that the earth moved. By decree it was decided that academic freedom to teach the Copernican Doctrine could no longer exist. Cardinal Baroni said, "The Holy Spirit intended to teach us how to go to Heaven, and not how the heavens go."

Kepler who had found the concealed riches in Copernicus' writings gave an outline of his basic ideas in Epitome Astronomiae Copernicanae, published in Linz and Frankfort, 1618-21. It was a very strong endorsement. Kepler's writings were promptly placed on the Index Librorum Prohibitorum. For the

rest of his life he had to suffer from endless needlings and the many consequences of the religious persecution mania of his time. Galileo was on the Index, too. Many others shared the same fate. The Copernican revolution began the critical phase of fighting for survival. For a long time the Doctrine was rejected. Individuals owning a copy of Copernicus were afraid even to mention names of persons on the Index. The revolution did not die. We are in the midst of it even now. Our television screens displaying the American astronauts in space looking with their cameras back to our planet earth bear eloquent testimony to it. Toward the end of his life Galileo made this trenchant statement--a thought just as true today as it was in 1543: "The greatest hatred in this world is created by ignorance in its hatred for knowledge."



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The woodcut of Copernicus found on the announcement of the third Annual Zinner Lecture shows Copernicus holding a flower in his hand. The flower has a symbolic significance. It depicts an attribute. The little flower is a "Maiglöckchen", a lily of the valley. Arriving in late April, breaking through snow and ice, its coming announces with sweet and mild fragrance the message that spring is here. The harsh winter is over. To the casual browser it may seem to be an accident to find in the Zinner Collection the unusual little volume:

Brunn, Walter von. Das Maiglöckchen; eine alte vielgerühmte Heilpflanze. Degen & Kurth, Duren, 1937. (QK99.B7)

Is it really an accident? No. The little book discusses the lily of the valley from a pharmaceutical standpoint and shows furthermore that it was used as a typical attribute of physicians. The book refers on page 34 to the above mentioned woodcut of Copernicus and gives many examples of portraits

of contemporary physicians, all with a lily of the valley in their hands.

The alcoholic extract of this plant contains some powerful drugs. Formerly used in the treatment of circulatory ailments and heart conditions, it is still used today under the name of cardiotonin which has been replaced now mostly by digitalis drugs. The latter are easier to standardize. Used as a remedy by physicians in the days of Copernicus and until the end of the 18th century, it became an attribute found on many paintings. It symbolizes the power to heal, but also courage, since it gives strength to the heart. The alcoholic extract of the plant was used as a precious medicine, kept in golden or silver vials. It was administered under the name Aqua aurea, eau d'or, Golden Water, or Gold Wasser.

The presence of this little book shows the Zinner Collection is more than a haphazard collection of books, mainly on the history of astronomy. This collection mirrors and reflects not only the achievements of a certain period, it also reflects contemporary human thought with all its attributes. Thus we have in the Zinner Collection a valuable tool for

the objective evaluation of human thought by other means than departmentalized knowledge.

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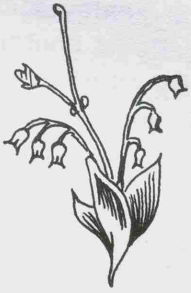

A GUIDE TO COPERNICANA IN THE MALCOLM A. LOVE LIBRARY

by

John D. Ambriano
Sciences Librarian

This is a revised and enlarged version of a similar guide prepared in 1969 by the Sciences and Engineering Library staff.

This bibliography is intended as a handy guide for the reader interested in locating materials on Copernicus in the Malcolm A. Love Library. For the serious student and scholar, two bibliographies of Copernicana are recommended: Edward Rosen's annotated Copernicus bibliography, 1939-1958, which is in the second edition of Three Copernican treatises, and Henryk Baranowski's Bibliografia kopernikowska, 1509-1955.

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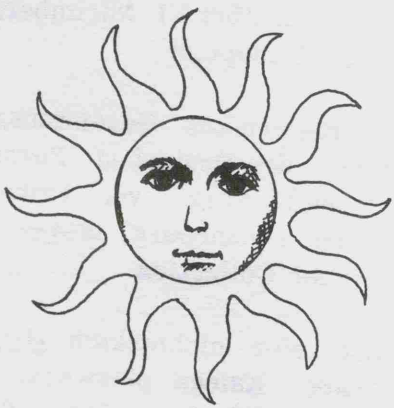

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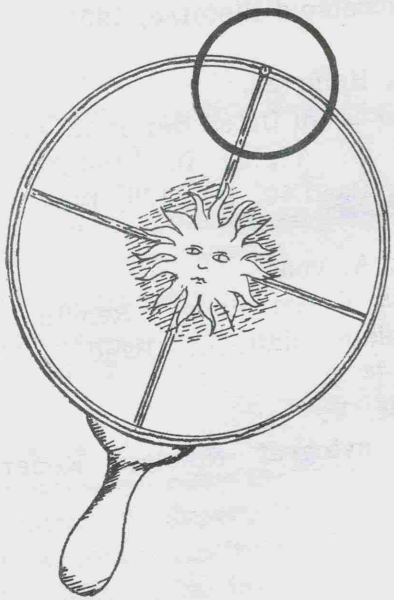

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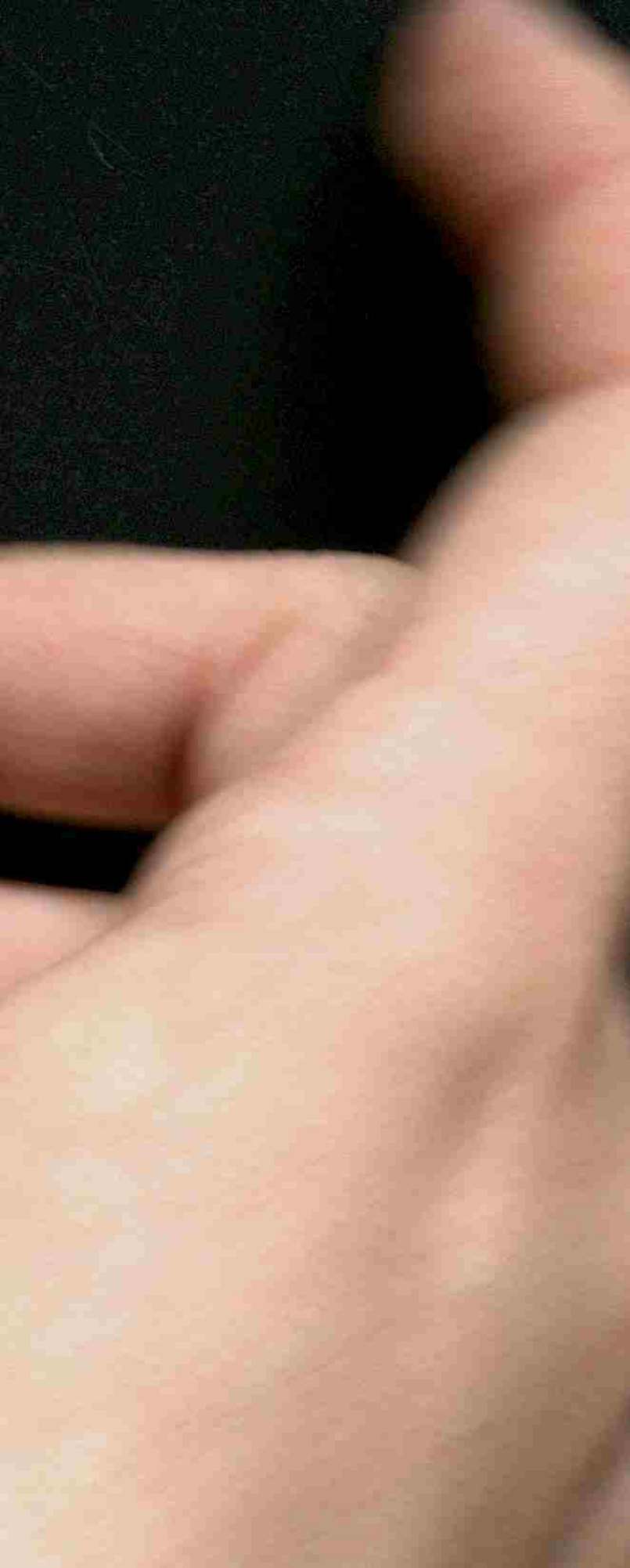

NICOLAUS COPERNICUS

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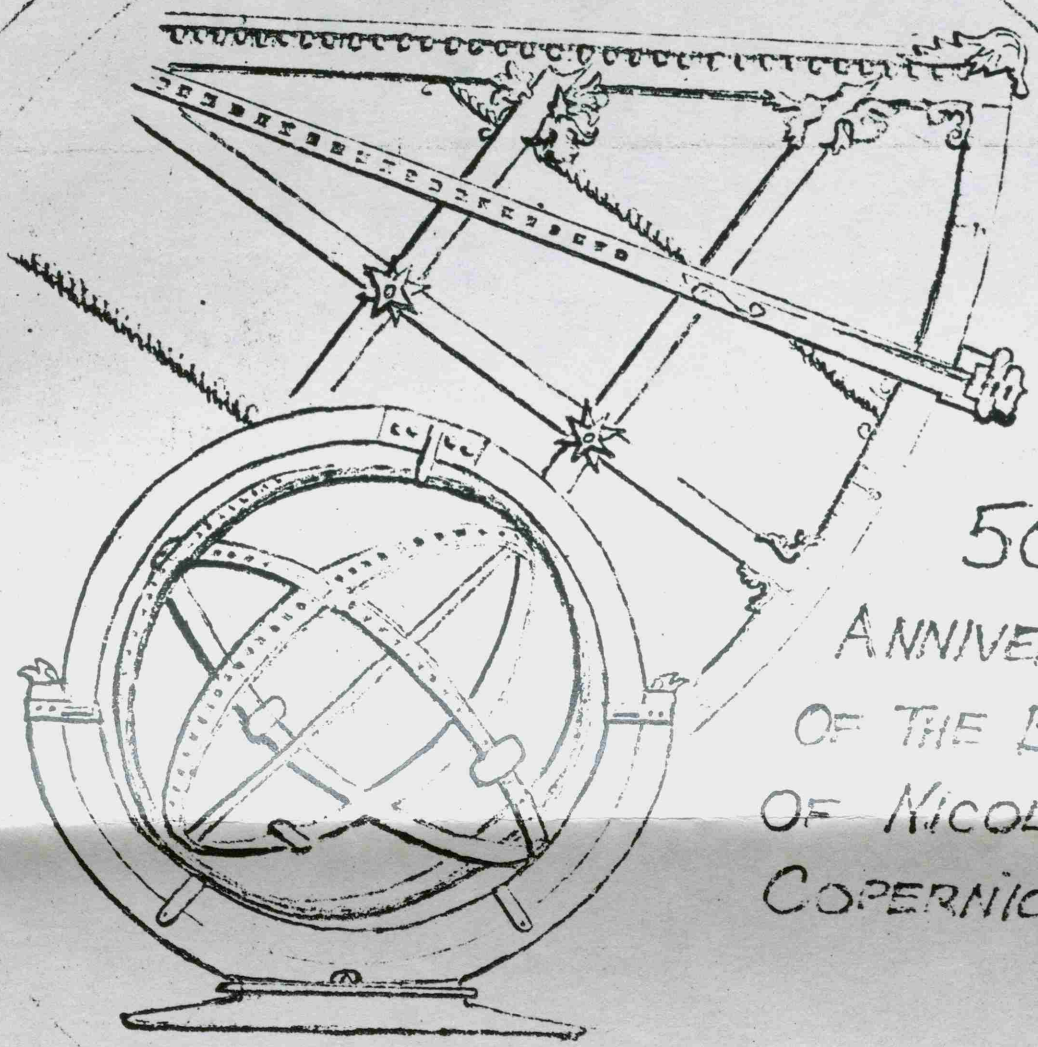

500TH
ANNIVERSARY
OF THE BIRTH
OF NICOLAUS
COPERNICUS

1473·1973

THE POLISH BOOK EXPOSITION

EXPOSITION DU LIVRE POLONAIS

NOVEMBER - NOVEMBRE 1973

THE POLISH BOOK EXPOSITION

EXPOSITION DU LIVRE POLONAIS

NOVEMBER-NOVEMBRE 1973

Whole wide world celebrates the 500th birth anniversary of the great Polish astronomer, Nicolai Copernicus. For this occasion was held the Extraordinary International Astronomic Union Congress in Poland, in many countries was organized science conferences and exhibitions. In Poland, as in other countries, was appeared a lot of publications dedicated Nicolai Copernicus.

All of these make a big accasion for bringing Poland - its science, culture, sensible contribution to the world science and universal progress - near other countries.

This year was proclaimed as the Polish Science Year. In connection with that many science works, emphesizing imperishable the great astronomer possesions, was appeared in whole world.

Copernicus discoveries became whole people property. Dissemination of those discoveries we indebted first of all for scientist and books. In Copernicus homeland, in contemporary Poland, the book is attainable for all our citizens. The publisher output is big. For example in 1973 we have published nearly 10 000 items in more than 150 millions editions.

And just for these two occasions - celebrations the 500th birth anniversary of Nicolai Copernicus and the Polish Science Year - at National Library in Ottawa suggestion we have occasion for presentation here, on Canadian land, the exhibition of Polish books, particularly the science books. On this exhibition we present nearly 1500 books issued in 1972 and 1973 mainly.

Zjednoczenie Księgarstwa /Book Trading Company/, qualificated for organization this exposition by Ministry of Culture and Art Polish People's Republic, express thanks National Library in Ottawa for its initiative and hospitality.
We hope Polish book will find many friends in Canada and presenting exhibitions will bring Polish and Canadian people much more closer together.
Being in this belief, we consign the Exhibitions of Polish Books over to Canadian public.

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Tout le monde civilisé célébre aujourd'hui la 500éme aniversaire de grand astronome polonais Nicolas Copernic. Le Congrés International d'Union Astronomique extraordinaire qui vient d'être organisé, des centaines de conférences scientifiques qui ont eu lieu dans différents pays, ainsi que des expositions, des initiatives éditrices et d'autres formes pour honorer le grand savant - tout cela donne lieu a un rapprochement de la Pologne au monde, rapprochement de sa culture, de sa science, de son apport scientifique important dans le développement de la science mondiale et dans le progrés de l'humanité.

C'est précisement le Jubilé de Nicolas Copernik qui fait que, sur l'initiative de Bibliothéque Nationale á Ottawa, nous pouvons montrer aujourd'hui, sur accueillante Terre Canadienne, cette exposition du livre polonais et en particulier du livre scientifique. Ce n'est qu'un large fragment, une présentation d'environs 1.500 titres des livres édités au cours de deux derniéres anneés.

Dans le pays de Nicolas Copernic, dans la Pologne d'aujourd'hui le livre est devenu accessible pour tous les citoyens. Seulement en 1973 nous éditons environs 7 milles de titres dont le tirage est plus de 150 milions d'exemplaires. L'anneé courante, l'année de jubilé du grand astronome a été proclamée l'Anné de Science Polonaise, dont l'acquis direct constituent, en outre, de nombreuses et originales oeuvres scientifiques qui éclairent aujourd'hui, avec le recul de cinq siécles, L'apport impérissable des penseés du grand Polonais.

Les découvertes de Nicolas Copernic sont devenues un bien commun de toute humanité progressiste. Leur popularisation est due tout d'abord au livre et aox hommes de science dont la passion révelatrice et la foi en progrés créent des valeurs nouveaux et impérissables.

L'Unité de Libraire qui au nom de Ministére de la Culture et des Beaux-Arts de République Populaire de Pologne, organise l'exposition présente, exprime ici sa reconnaissance a la Bibliothéque Nationale a Ottawa pour sa initiative et pour sa bienveillance. Nous sommes persuadés que le livre polonais trouvera au Canada de nombreux amis et que l'exposition présentée deviendra un apport précieux et utile dans l'oeuvre de coopération humaniste de tous les pays en général et de Pologne et Canada en particulier Convaincus de cela, nous remettons l'exposittion de livre polonais mains de public canadien.

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WYDAWNICTWO "ARKADY"
Przedsiębiorstwo Państwowe

"ARKADY" PUBLISHERS
State Enterprise

ÉDITIONS "ARKADY"
Entreprise Nationale

Warszawa ul.H.Sienkiewicza 14

Established 1957 by fusion of two publishing houses: "BUDOWNICTWO I ARCHITEKTURA" and "SZTUKA". Scope of activity: building trade, town-planning, architecture and art; scientific studies, popular science books, professional literature, textbooks for university-level schools, albums; periodicals.

Fondées en 1957 /par fusion des maisons d'édition "BUDOWNICTWO I ARCHITEKTURA" et "SZTUKA". Domaine d'activité; bâtiment, urbanisme, architecture et beaux-arts; ouvrages scientifiques et de vulgarisation, ouvrages de spécialisation, manuels pour l'enseignement supérieur, albums, revues.

Anderman F.	Tarcze prostokątne. Obliczenia statystyczne
Bąbiński Cz., Chorobiński A.	Metody optymalizacji w projektowaniu planów
Bietkowski H.	Świat Kopernika w. angielska 1973
Błaszczyk W.	Projektowanie sieci kanalizacyjnych 1965
Bochenek A., Buczkowski K.	Rzemiosło artystyczne w Polsce / wersja angielska/ 1972
Bogucki W.	Budownictwo stalowe 1967
Brędka J., Łubiński M.	Lekkie konstrukcje stalowe 1970
Broniewski S.	Ekonomiczne podstawy planowania wielkości miast. /wersja angielska/ 1973

Bukowski B.	Technologia betonu t.1, cz.1 spoiwo, woda
Bukowski B.	Projektowanie betonów. Zagadnienia ogólne p fabrykacji 1972. Drogi, lotniska, koleje, budowle podziemne
Bzymek Z.	Zastosowanie maszyn cyfrowych do analizy statystycznej konstrukcji 1966
Czarny W.	Architektura zespołów osiedleńczych 1972
Gąsiorowski E.	Ratusz w Toruniu 1970
Goldzamt E.	Urbanistyka krajów socjalistycznych 1971
Jastrzębski P., Solecki R., Szymkiewicz J.	Kratowice.Obliczenia statystyczne 1970
Kaczkowski Z.	Płyty. Obliczenia statyczne 1968
Kobiak J., Stachurski W.	Konstrukcje żelbetowe cz. 1 1969
Kobiak J., Stachurski W.	Konstrukcje żelbetowe cz. 2 1969
[illegible]ołodziejczyk L.	Gospodarka cieplna w ogrzewnictwie 1972
[illegible]ostrowicki J.	Polska /w. angielska/ 1973
Kostyrko K., Okołowicz-Grabowska B.	Pomiary i regulacja wilgotności w pomieszcze-
Krzyszczuk H.	niach 1971
Leśniak Z.	Zastosowanie elektrycznej techniki obliczenio- wej w inżynierii sanitarnej 1969
Lorentz S., Biegański P., Zachwatowicz J.	Metody optymalizacji konstrukcji przy zastoso- waniu maszyn matematycznych 1970
Malisz B.	Stare Miasto i Zamek Królewski w Warszawie 1971
Michałowski K., Dziewanowski	Zarys teorii kształtowania układów osadniczych /w. francuska/ 1971
Michałowski K., Dziewanowski	Palmyra /w. ang./ 1970
Michałowski K., Dziewanowski	Karnak / w. franc./ 1972
	Aleksandria /w.niem./1971

Michałowski K., Dziewanowski	Luksor /w.franc./ 1972
Michałowski K., Dziewanowski	Piramidy i mastaby 1972
Mielcarzowicz B.	Melioracje terenów miejskich i przemysłowych
Nitzel A., Stachurski W.	Awarie konstrukcji betonowych i murowanych 1973
Nowacki W.	Dynamiki budowli 1972
Nowacki W.	Teoria pełzania /wersja francuska/ 1965
Pawlikowski M.	Forma przestrzenna zagrody. 1970
Petrozolin W.	Projektowanie sieci wodociągowych 1967
Praca zbiorowa	Budowle piętrzące 1972
Praca zbiorowa	Fizyczno-chemiczne badania ścieków miejskich
Praca zbiorowa	Mały ilustrowany słownik budowlany 1971
Praca zbiorowa	Oczyszczanie ścieków miejskich. Podstawy technologiczne i zasady projektowania. t. I/II
Praca zbiorowa	Kształtowanie terenów zieleni. 1973
Praca zbiorowa	Gdańsk, jego dzieje i kultura. 1969
Praca zbiorowa pod red.Szablowskiego	Zbiory Zamku Królewskiego na Wawelu /w. angielska/ 1971
Romski A.	Frombork 1973
Rzymkowski A., Chowaniec M.	Ruralistyka. Planowanie obszarów rolniczych i budownictwo wiejskie 1972
Sadowski J.	Akustyka w urbanistyce, architektura i budownictwo 1971
Skalmowski W.	Chemia materiałów budowlanych. 1971
Słowińska J.	Ekspresja sił w nowoczesnej architekturze. 1969
Solecki R., Szymkiewicz J.	Układy prętowe i powierzchniowe. Obliczenia dynamiczne. 1964
Szafer T.P.	Nowa architektura polska. Diariusz lat 1966-1970 1972

Twarowski N.	Słońce w architekturze /w. franc./ 1967
Walden H., Stasiak J.	Mechanika cieczy i gazów w inżynierii sanitarnej
Wejchert K.	Miasto w warsztacie 1969
Wisłocka J.	Awangardowa architektura polska 1918 - 1939
Wisłocka J.	Dom i miasto jutra 1971
Zachwatowicz J.	Architektura polska /w. angielska/ 1967
Zienkiewicz O.C.	Metoda elementów skończonych 1972
Ziółko J.	Zbiorniki metalowe na ciecze i gazy 1970
Zonn W.	Świat Kopernika w. francuska 1973

SPÓŁDZIELNIA WYDAWNICZA
"CZYTELNIK"

"CZYTELNIK" PUBLISHING
COOPERATIVE

COOPÉRATIVE D'ÉDITION
"CZYTELNIK"

Warszawa ul. Wiejska 12a

Established 1944. Scope of activity: Polish and foreign contemporary literature, Polish and foreign classics, memoirs, political and journalistic writings, essays, books for children and young people.

Fondée en 1944. Domaine d'activité: littérature contemporaine polonaise et mondiale, classiques polonais et étrangers, souvenirs et mémoires, littérature politique, économique et culturelle, reportages, essais, livres pour les enfants et la jeunesse.

Andrzejewski J.	Prometeusz 1973
Buczkówna M.	Dwie przestrzenie 1973
Bellow	Herzog /1971/
Böll	Koniec podróży służbowej 1969
Braun A.	Śladami Conrada 1972
Breza T.	Śpiżowa brama 1973
Breza T.	Zawiść 1973
Breza T.	Niebo i ziemia. t. I/II 1972
Brzechwa J.	100 bajek 1973
Cather	Poranek Wagnerowski 1971
Compton-Burnett	Teraźniejszość i przeszłość 1972
Dąbrowska M.	Przygody człowieka myślącego /1973/

Dąbrowska M.	Opowiadania /1972/
Dygat S.	Pożegnania 1973
Foulkner W.	Wściekłość i wrzask 1971
Górzalski	Kontrabanda 1973
Herbert Z.	Barbarzyńca w ogrodzie 1973
Homer	Odyseja 1970
Horacy	Do Leukonoe 1973
Iwaszkiewicz J.	Opowiadania muzyczne 1971
Iwaszkiewicz J.	Nowa miłość 1973
Kijowski	Oskarżony 1973
Konwicki T.	Zwierzoczłekoupiór 1972
Krzysztoń J.	Kamienne niebo 1973
Kuncewiczowa M.	Tristan 1946 /1972/
Lem S.	Głos Pana 1970
Lem S.	Opowieść o pilocie Pirxie 1973
Lenz	Lekcja niemieckiego 1971
Leśmian B.	Klechdy sezamowe 1973
Marcjalis	Epigramy 1971
Merle	Zwierzę obdarzone rozumem 1971
Mickiewicz A.	Pan Tadeusz
Mickiewicz A.	Pan Tadeusz
Musset	Dwie komedie i jedno przysłowie 1971
Nałkowska Z.	Medaliony 1972
Newerly I.	Pamiątka z celulozy /1973/
Newerly I.	Żywe wiązanie 1971
Nowak	A jak królem, a jak katem. 1972
Phis	Pierwsza zima w życiu Emannuela 1970
Potocki W.	Parady /1966/

Rousseau de la Valetto	Miłostki królewskie 1971
Roztworowski	Z okna widać 1973
Różewicz	Wycieczka do muzeum 1972
Seanz	Siedemdziesiąt razy siedem 1972
Shakespeare W.	Poskromienie złośnicy /1972/
Siemieniecka	Słomkowy Łańcuszek 1969
Stawiński	Pamiętnik z trzech mórz 1973
Stojowski	Zamek w Karpatach 1973
Stryjkowski	Głosy w ciemności 1972
Szmaglewska S.	Dymy nad Birkenau /1973/
Tuwim J.	Kwiaty polskie 1973
Vercors	Tratwa Meduzy 1972
Wawrzkiewicz	Przed sobą 1973
Ważyk A.	Od Rimbauda do Eluarda 1973
Załuski	Czterdziesty czwarty /1973/
Żakiewicz	Kraina Sto Piąte j Tajemnicy 1972
Żeromski S.	Puszcza jodłowa 1973
Żukrowski W.	Z kraju milczenia 1972

WYDAWNICTWO HARCERSKIE
"HORYZONTY"

"HORYZONTY" PATHFINDERS
PUBLISHING HOUSE

ÉDITIONS DE L'UNION
DES ÉCLAIREURS "HORYZONTY"

Warszawa, ul.M.Konopnickiej 6

Established 1958. Scope of activity: methodical, training and repertoire books connected with the activity of the Polish Pathfinders League; books for youth, social, political and popular science literature; handbooks; periodicals.

Fondées en 1958. Domaine d'activité: ouvrages de formation, d'education et d'instruction liés au programme d'action de l'Union des Eclaireurs Polonais; livres pour la jeunesse, littérature socio-politique et de vulgarisation scientifique; guides et vade-mecum; revues.

Bratkowski S.	Księga wróżb prawdziwych
Dańkowska M.	W cztery oczy wyd. II
Elsztein P.	W Kosmosie wyd. I
Nowak Z.	Mu - terere
Praca zbiorowa	Kiedy to się zaczyna
Praca zbiorowa	Biało-czerwoną ścieżką wyd.I
Żiółkowska W.	Dzieci Departamentu Sekwany

TYTUT WYDAWNICZY
TRALNEJ RADY ZWIĄZKÓW
ODOWYCH

LISHING INSTITUTE OF THE
TRAL COUNCIL OF TRADE-UNIONS

STITUT D'ÈDITION DU CONSEIL
TRAL DES SYNDICATS

rszawa, ul.Spasowskiego 1/3

tablished 1950. Scope of activity: publications on the theory
d history of the Polish and international trade-union movement,
cial and political literature /especially economic problems,
fety and hygiene of work, culture and rest/, publications com-
ssioned by the Central Council of Trade-Unions and by the par-
icular trade-unions; periodicals.

ondé en 1950. Domaine d'activité: ouvrages consacrés á la thé-
rie et á l'histoire du mouvement syndical polonais et interna-
ional, ouvrages socio-politiques /compte particuliérement tenu
es problémes économiques, de la sécurité et de l'hygiéne du
ravail, de la culture et des loisirs/, publications commandé-
s par le Conseil Central des Syndicats et par les Bureaux des
ivers syndicats professionnels; revues.

Kieszczyński L.	Kronika ruchu zawodowego w Polsce 1808 - 1939
Roset E.	Demografia polska w służbie postępu społecznego
Zygulski K.	Wstęp do zagadnień Kultury .

WYDAWNICTWO "INTERPRESS"

"INTERPRESS" PUBLISHERS

ÉDITIONS "INTERPRESS"

Warszawa, ul.Bagatela 10

Established 1967 by fusion of two publishing houses: "POLONIA" and "ZACHODNIA AGENCJA PRASOWA". Scope of activity: publications on contemporary Poland /especially on its political problems/ and on Polish history; popular science books, guide-books, albums; periodicals.

Fondeés en 1967 /par fusion des éditions "Polonia" et de "Zachodnia Agencja Prasowa". Domaine d'activité: livres consacrés á la Pologne contemporaine /particuliérement aux questions politiques/ et á l'histoire de Pologne; ouvrages de vulgarisation scientifique; guides touristiques, albums, revues.

Adamczewski J.	Kopernik i Jego Epoka. w. pol.
Adamczewski J.	Kopernik i Jego Epoka. w. ang.
Adamczewski J.	Polskie Miasta Kopernika w. pol.
Adamczewski J.	Polskie Miasta Kopernika w. ang.
Adamczewski J.	Jesteśmy w Krakowie w.pol.
Arczyński	W Sudetach Kłodzkich w. ang.
Bajcer	Polska. Przewodnik Turystyczny. w. pol.
Bajcer	Polska. Przewodnik Turystyczny w. franc.
Bajcer	Polska. Przewodnik Turystyczny w. ang.
Biskup M., Dobrzycki J.	Mikołaj Kopernik Uczony i Obywatel w. pol.

Biskup M., Dobrzycki J.	Mikołaj Kopernik Uczony i Obywatel w. ang.
Biskup M., Dobrzycki J.	Mikołaj Kopernik - folder w. franc.
Biskup M., Dobrzycki J.	Mikołaj Kopernik - folder w. ang.
Bożyk	Polska jako partner handlowy w. pol.
Bożyk	Polska jako partner handlowy w. franc.
Czarnowski	Beskid Niski w.ang.
Fuksiewicz	Film w Polsce w.pol.
Fuksiewicz	Film w Polsce w.franc.
Jankowski	Warszawa 1945 i Dziś w.pol.
Jankowski	Warszawa 1945 i Dziś w.franc.
Januszkiewicz	Edukacja w Polsce w. franc.
Lorentz	Przewodnik po Muzeach i Zbiorach w Polsce w. pol.
Małek i Nyka	W Pieninach w.ang.
Małek i Nyka	W Beskidzie Sądeckim w. ang.
Nyka	W Tatrach Polskich w.ang.
Nyka	W górach w.ang.
Praca zbiorowa	Polska w Kalejdoskopie w.pol.
Praca zbiorowa	Polska w Kalejdoskopie w.ang.
Praca zbiorowa	Polska 1972. Kraj i ludzie. w. pol.
Rutkiewicz	Wrocław wczoraj i dziś. w. pol.
Sumiński	W Beskidzie Żywieckim i na Orawie w. pol.
Szermer	Gdańsk, przeszłość i współczesność w. pol.
Szermer	Gdańsk, przeszłość i współczesność w. ang.
Szydłowski	Teatr w Polsce w. pol.
Szydłowski	Teatr w Polsce w. franc.
Trzeciak P.	Przez polskie ziemie w.pol.

Trzeciak P. Przez polskie ziemie w. franc.

Trzeciak P. Przez polskie ziemie w.ang.

PAŃSTWOWE WYDAWNICTWO
"ISKRY"

"ISKRY" STATE PUBLISHING
HOUSE

ÉDITIONS NATIONALES
"ISKRY"

Warszawa, ul.Smolna 11/13

Established 1952. Scope of activity: literature for youth, contemporary Polish and foreign literature, social and political literature, journalistic reports from Poland and abroad; publications commissioned by the Socialist Youth Union /ZMS/, Peasant Youth Union /ZMW/ and Polish Students Association /ZSP/; popular science studies; periodicals.

Fondées en 1952. Domaine d'activité: livres pour la jeunesse, littérature contemporaine polonaise et étrangére, ouvrages socio-politiques, reportages sur la Pologne et les autres pays, publication de l'Union de la Jeunesse Socialiste /ZMS/, de l'Union de la Jeunesse Rurale /ZMW/ et de l'Association des Etudiants Polonais /ZSP/, ouvrages de vulgarisation scientifique; revues.

Antologia	Diabli wiedzą co
Brandys M.	Koniec świata szwoleżerów t. I/II
Broszkiewicz I.	Samotny podróżny
Fiedler A.	Kanada pachnąca żywicą
Gross O., Gryżewski K.	Podróż w świecie znaczków
Kosidowski Z.	Opowieści biblijne

Kowalik M.	Sztokholmskie abecadło
Woźniakowski J.	Zapiski kanadyjskie
Wybór	Debiuty poetyckie
Zakrzewski J.	Iberyjskie wędrówki
Zbiorowe	Opowieści hiszpańskie
Zonn W.	Rewolucja kopernikowska

SPÓŁDZIELNIA WYDAWNICZA
"KSIĄŻKA I WIEDZA"

"KSIĄŻKA I WIEDZA"
PUBLISHING COOPERATIVE

COOPÉRATIVE D'ÉDITION
"KSIĄŻKA I WIEDZA"

Warszawa, ul.Smolna 13

Established 1918. Scope of activity: classics of Marxism-Leninism; works on economics, philosophy, history of the Polish and international working class movement; publications commissioned by the Central Committee of the Polish United Workers' Party; social and political literature, journalistic writings on politics and culture; memoirs of civic and revolutionary leaders; Polish and foreign fiction; scientific studies, popular science books; periodicals.

Fondée en 1918. Domaine d'activité: classiques du marxisme-léninisme, ouvrages économiques et philosophiques, histoire du mouvement ouvrier polonais et international, publications du Comité Central du Parti Ouvrier Polonais Unifié, littérature socio-politique et culturelle, reportages, mémoires et souvenirs de militants sociaux et révolutionnaires, littérature polonaise et étrangére, ouvrages scientifiques et de vulgarisation, revues.

Ajnenkiel A.	Spór o model parlamentaryzmu polskiego do 1926 roku. 1972
Lauer Brand H.	Pisma i przemówienia. 1970

Cackowski Z.	Główne zagadnienia i kierunki filozofii, wyd. V. 1973
Cieślak T.	Oranienburg-Sachsenhausen hitlerowskie obozy koncentracyjne, 1933 - 1945. 1972
Czyżewski L.	Wspomnienia dowódcy obrony Zakroczymia w 1939
Dziamski S.	U źródeł marksistowskiej filozofii nauk społecznych w Polsce 1972
Engels F.	Rozwój socjalizmu od utopii do nauki 1971
Góra W.	Powstanie władzy ludowej w Polsce 1972
Grünberg K.	Polskie koncepcje federalist. 1864-1918
Grzybowski S.	Mikołaj Kopernik wyd.II 1973
Grzybowski K.	Refleksje sceptyczne t.I/II wyd.II
Hillbrand B.	Konspiracyjne organizacje młodzieżowe w Polsce 1973
Hinz H.	Filozofia Hugona Kołłątaja 1973
Jabłoński H.	Rewolucja Październikowa a sprawa niepodległości Polski 1967
Jabłoński H., Kruczkowski A.	Wielka Rewolucja Październikowa Socjalistyczna a Polska 1967
Jakuszewski I.T.	Leninizm i "sowietologia" 1973
Hanna i Tadeusz Jędruszczak	Ostatnie lata II Rzeczpospolitej 1935-1939, 1970
Kaleniczenko P.	Polacy w Rewolucji Październikowej i wojnie domowej na Ukrainie 1917-1930
Kalicka F., Brun-Bronowicz J.	Życie, działalność, twórczość 1973
Kirchmayer J.	W kraju i na obczyźnie 1971
Kirchmayer J.	Powstanie Warszawskie, wyd.VI 1970
Kowalak T.	Zagraniczne kredyty dla Niemców w Polsce 1919-1939 1972
Kowalak T.	Prasa niemiecka w Polsce 1918 - 1939 1971

Kowalski W.T.	Polityka zagr. RP 1944-1947 1971
Kowalski W.T.	Walka dyplomatyczna o miejsce Polski w Europie 1939-1945, wyd.IV 1972
Królikowski L.	Wybór pism, 1972
Kukułka J.	Francja a Polska po traktacie wersalskim
Landau Z., Tomaszewski J.	Robotnicy przemysłowi w Polsce 1918-1939 1971
Landau Z., Tomaszewski J.	Zarys historii gospodarczej Polski 1918-1939, wyd.III 1971
Lech M.	Hugo Kołłątaj /Światowid/ 1973
Lenin W.I.	Dziecięca choroba "lewicowości" w komunizmie 1970
Lenin W.I.	Państwo a rewolucja 1972
Limanowski B.	Pamiętniki t.IV 1919-1928 1973
Luksemburg R.	Listy do Leona Jogichesa Tyszki t. III 1971
Marchlewski J.	Idee, czasy, ludzie 1973
Engels F.,Marks K.	Manifest Komunistyczny wyd. XXVI 1969
Mikulicz S.:	Prometeizm w polityce II Rzeczpospolitej 1971
Nasiłowski M.	Ekonomia polityczna socjalizmu w.II 1973
Ogonowski Z.	Locke 1972
Pęcherski M.	Problemy i perspektywy rozwoju szkolnictwa w Polsce Ludowej 1973
Polny R.	Systemy szkolnictwa w krajach kapitalistycznych i socjalistycznych 1973
Praca zbiorowa	Wielkomiejski rozwój Warszawy do 1918 r.
Praca zbiorowa	Odgłosy Rewolucji Październikowej na Mazowszu i Podlasiu 1970
Praca zbiorowa	Okupacja i ruch oporu."Dziennik Hansa Franka" 1939-1945, t. I/II, wyd.II

Praca zbiorowa	Ponad ludzką miarę. Wspomnienia operowanych w Ravensbruck, wyd. III 1972
Praca zbiorowa	Okupacja i medycyna. 1971
Praca zbiorowa	Teheran-Jałta-Poczdam, wyd. II 1972
Praca zbiorowa	Pamiętniki emigrantów. Kanada. Nr 1-16 1971
Proektor D.M.	Agresja i katastrofa. 1973
Prosper H., Lissagaray O.	Historia Komuny Paryskiej. wyd.II 1971
Próchnik A.	Wybór publicystyki 1971
Przygoński A.	Polska w walce z okupantem hitlerowskim 1939-1945 1971
Przygoński A.	Udział PPR i AL w Powstaniu Warszawskim 1970
Reed J.	Dziesięć dni, które wstrząsnęły światem wyd. IV, 1970
Rusiński W.	Rozwój gospodarczy ziem polskich, wyd.III
Standziak M.:	Modlin. Obrona twierdzy w 1939 roku. 1970
Such J.	O uniwersalności praw nauki. 1972
Świdzińska N.	Polska 1944-1971. Fakty i liczby 1973
Turlejska M.	Prawdy i fikcje. Wrzesień 1939, grudzień 1941, wyd. II, 1968
Tyranowski J.	Traktaty sojusznicze Polski Ludowej 1972
Tyranowski J.	VI Zjazd PZPR 6-11 grudnia 1971 roku. Stenogram 1972
Tyranowski J.	VI Zjazd PZPR /wersje w jęz.ang. i franc./
Wanat L.	Za murami Pawiaka. wyd.V 1972
Wiatr J.J.	Marksistowska teoria rozwoju społ.1973
Wiatr J.J.	Naród i państwo, wyd.II 1973
Wójcicki J.	Dzieje Polski nad Bałtykiem 1972
Wroński S., Zwolakowa M.	Polacy - Żydzi 1939 - 1945 1971

Wudel W. — Filozofia strachu i nadziei 1971

Siuchniński M., Kobyliński S. — Ilustrowana kronika Polaków, wyd.II 1971

Żychowski M. — Bolesław Limanowski 1835 - 1935, 1971

Żwierkowski W. — Rys powstania, walki i działalności Polaków 1830 - 1831

LUDOWA SPÓŁDZIELNIA WYDAWNICZA

PEOPLE'S COOPERATIVE
PUBLISHERS

COOPÉRATIVE PAYSANNE
D'ÉDITION

Warszawa, ul.Grzybowska 4/8

Established 1945. Scope of activity: history, social and political literature /especially the history of the peasant movement in Poland/; Publications commissioned by the United Peasants Party; classical and contemporary fiction /especially connected with rural problems/; scientific studies, popular science books; periodical.

Fondée en 1945. Domaine d'activité: histoire, ouvrages sociopolitiques /compte particuliérement tenu de l'histoire du mouvement paysan en Pologne/; publications du Comité Directeur du Parti Paysan Unifié /ZSL/, littérature classique et contemporaine /surtour consacrée au monde rural, ouvrages scientifiques et de vulgarisation, revue.

Centkowski J.	Fromborski samotnik 1973, wyd.I
Dużyk J.	Droga do Bronowic. Opowieści o Lucjanie Rydlu. 1972 wyd.II
Helsztyński S.	Przybyszewski 1973, wyd. III
Horacy	Pieśni. 1973 wyd. I
Kaltenbergh L.	Ogień strzeżony. Opowieść o Stanisławie Wyspiańskim 1972, wyd. IV

Kapaniak J.	Ród Gąsienniców. Konary. Krwawi i hyrni. 1972 wyd. III
Kraszewski J.I.	Stara baśń. Opowieść IX wieku. 1971 wyd. I
Kuriata Cz.	Miłość legendą innych. 1972 Wyd.I
Łoziński J.	Chłopska wysokość 1972 wyd. I
Mrówczyński B.	Miecz kaganowy. t.1/2 /Armia milcząca/ 1973 wyd. II
Nyrkowski S.	Karnawał dziadowski. 1973 wyd. I
Ożóg J.B.	Wybór opowiadań 1972 wyd. I
Rosnowska J.	Dzieje poety. Opowieść o Wincentym Polu. 1973 wyd. II
Rusinek M.	Pluton z dzikiej łąki. Ziemia miodem płynąca. 1973 wyd. IV
Szczawaj J.	Antologia współczesnej poezji ludowej. 1972 wyd. II
Świrko S.	Z pieśnią i karabinem. Pieśni partyzanckie i okupacyjne z lat 1939-1945. 1972 wyd. I

INSTYTUT WYDAWNICZY
"NASZA KSIĘGARNIA"

"NASZA KSIĘGARNIA"
PUBLISHING INSTITUTE

INSTITUT D'ÉDITION
"NASZA KSIĘGARNIA"

Warszawa, ul.W. Spasowskiego 4

Established 1921. Scope of activity: books for children and young people; popular science and pedagogical publications; periodicals.

Fondé en 1921. Domaine d'activité: livres pour les enfants et la jeunesse, ouvrages de vulgarisation scientifique et de pédagogie, revues.

Baum	Czarnoksiężnik ze szmaragdowego grodu
Bahdaj	Podróż w nieznane
Beylin-Styczyński	Wędrówka po Warszawie
Brzostkowski	Mikołaj Kopernik i Jego nauka
Chotomska	Dzień dobry królu Zygmuncie
Chotomska	Klucze do jelenia
Gorzechowska	Od Łowicza grają gracze
Gorzechowska	Niedaleko od Rzeszowa
Graves	Mity starożytnej Grecji
Jerzyna	Wśród drzew
Koszutska	Czerwony samochodzik
Kubiak	List do Warszawy
Kurkiewicz	Pięć żywiołów Arystolesa
Lear	Dong co ma świecący nos

Papuzińska	A gdzie ja się biedusieńki podziejem
Praca zbiorowa	Klechdy Monowe
Przecławski	Turystyka i wychowanie
Rubinowicz	Rozmowy o fizyce
Stiller	Narzeczony z morza
Suchodolski	Nasza współczesność a wychowanie
Thoger	Szanta
Thoger	Kalendarz dziecka 1973
Thoger	Kosmos Kinderkalender 1974 w jęz. niem.
Trzeciak	250 razy o sztuce polskiej
Trzeciak	Kolorowy świat - rzecz o grafice polskiej
Wdowiński	Polska w kolorach
Wernerowa	To i owo o zwierzętach
Wernerowa	Sekrety delfinów
Woroszylski	Mniejszy szuka dużego
Zagała	Najkrótsze bajki
Zdzitowiecka	Pantofelek pięknej Rodopis
Żukrowski	Porwanie w Tiutiurlistanie

PAŃSTWOWE PRZEDSIĘBIORSTWO
WYDAWNICTW KARTOGRAFICZNYCH

STATE CARTOGRAPHICAL
PUBLISHERS

ENTREPRISE NATIONALE
D'ÉDITIONS CARTOGRAPHIQUES

Warszawa,ul. Solec 18

Established 1951. Scope of activity: maps, geographical and historical atlases, publications on land-surveying and cartography; scientific studies, textbooks and teaching aids.

Fondée en 1951. Domaine d'activité: cartes, atlas géographiques et historiques, ouvrages de géodésie et de cartographie; ouvrages scientifiques, manuels et aides scolaires.

Hausbrandt St.	Rachunek wyrównawczy i oblicz. geodez. T.I. wyd. 1970r.
Hausbrandt St.	Rachunek wyrównawczy i oblicz. geodez. T.II. wyd. 71 r.
Lipiński Cz.	M.Geodezja T.I. wyd. 1971
Odlanicki-Poczobut	M.Geodezja wyd. 1971
Opalski W., Cichowicz L.	Astronomia geodezyjna wyd. 1 1970
Piasecki M.B.	Fotogrametria lotnicza i naziemna wyd. 1973
Praca zbiorowa	Atlas historyczny Polski 1973
PPWK	Polska Mapa Przeglądowa, 1:1 mln. /wersja kopernikowska/

PPWK	Plan Torunia 1973
PPWK	Plan Krakowa Centrum 1973
PPWK	Mapa Samochodowa Polski 1:1 mln. /szlak Kopernikowski/ 1973
PPWK	Powszechny Atlas Świata wyd. 1
Sawicki K.	Pięć wieków geodezji polskiej wyd. 1968
Szymoński J.	Instrumentoznawstwo geodez. cz.I wyd. 1968
Szymoński J.	Instrumentoznawstwo geodez. cz. II wyd. 1971
Szymoński J.	Instrumentoznawstwo geodez. cz. III wyd. 1972

PAŃSTWOWE WYDAWNICTWO
EKONOMICZNE

STATE ECONOMIC PUBLISHERS

ÉDITIONS ÉCONOMIQUES
DE POLOGNE

Warszawa, ul.Niecała 4a

Established 1949, up to 1961 known as "POLSKIE WYDAWNICTWA GOSPODARCZE". Scope of activity: publications on all problems of economics; scientific studies, popular science books, handbooks and university-level text-books; periodicals.

Fondées en 1949 /jusqu'en 1961 "Polskie Wydawnictwa Gospodarcze"/. Domaine d'activité: ouvrages de toutes les disciplines des sciences économiques; ouvrages de vulgarisation et de spécialisation, manuels universitaires; revues.

Adamiecki K.	O nauce organizacji
Adamiecki K.	Zarys ekonometrii
Bożyk P.	Korzyści z międzynarodowej współpracy
Gackowski Z.	Informatyka w zarządzaniu
Kamecki Z.	Międzynarodowe stosunki ekonomiczne wyd. II
Kamecki Z.	Ubezpieczenie majątkowe wyd. IV
Kudliński R.	Strategie wielkich korporacji
Kunert J.	Technika handlu morskiego
Kunert J.	Ekonomia polityczna socjalizmu, wybór tekstów

Kunert J.	Konsumpcja w gospodarce planowej
Lange O., Banasiński A.	Teoria statystyki wyd. II
Lange O.	Dzieła, tom I "Kapitalizm"
Łoś J.	Gospodarka żywnościowa w zmieniającym się świecie
Madej Z.	Nauka a rozwój gospodarczy wyd. II
Madej Z.	Elementy rachunku ekonomicznego
Pierla I.	Gospodarka przemysłu Polski
Praca zbiorowa	Kuchnia polska
Rączkowski S.	Międzynarodowe stosunki finansowe
Rączkowski S.	Twórcy naukowych podstaw organizacji
Rutkowski J.	Ekonomia polityczna kapitalizmu
Rutkowski J.	Wielkie korporacje
Rutkowski J.	Społeczne warunki funkcjonowania przedsiębiorstwa przemysłowego
Rutkowski J.	Polityka społeczna i służby społeczne PRL
Rutkowski J.	Rocznik polityczny i społeczny 1972
Sadowski W.	Statystyka dla ekonomistów tom II wyd. II
Sadowski W.	Statystyka dla ekonomistów tom II wyd. II
Secomski K.	Elementy polityki ekonomicznej
Sulmicki P.	Planowanie i zarządzanie gospodarcze
Szefler S.	Wczoraj, dziś i jutro gospodarki Polski
Szefler S.	Historia gospodarcza świata XIX i XX wieku wyd. II
Szulc B.	Statystyka dla ekonomistów tom I wyd. IV

Timofiejuk I.	Mierniki wzrostu ekonomicznego
Timofiejuk I.	Polityka społeczna
Zasępa R.	Metoda reprezentacyjna
Zawadzki S.M.	Polska, przestrzeń - społeczeństwo

PAŃSTWOWE WYDAWNICTWO NAUKOWE

POLISH SCIENTIFIC PUBLISHERS

ÉDITIONS SCIENTIFIQUES
DE POLOGNE

Warszawa, ul.Miodowa 10

Established 1951. Scope of activity: publications on the humanities, mathematics and natural sciences, the fundamental technical sciences; encyclopaedias, dictionaries and reference books; scientific studies, popular science books, textbooks and supplementary literature for university-level schools; periodicals.

Fondées en 1951. Domaine d'activité: sciences humaines, mathématiques et naturelles, sciences techniques fondamentales; encyclopédies, dictionnaires, mémentos; ouvrages scientifiques et de vulgarisation, manuels et ouvrages universitaires auxiliaires; revues.

Baranowski H.	Bibliografia Kopernikowska t. 1 1509 - 1555, t. 2 1955-65
Biskup M.	Działalność publiczna Mikołaja Kopernika
Biskup M.	Nicolas Coppernicus in Offentlichem Leben Polones
Biskup M.	Nowe materiały do działalności publicznej Mikołaja Kopernika z lat 1512-1555
Cackowski S.	Mikołaj Kopernik jako ekonomista
Czarkowski J.	Myśl ekonomiczna Mikołaja Kopernika

Cynarski S.	Znajomość nauki Mikołaja Kopernika w Polsce XVIII i XVII wieku
Cynarski S.	Reception of the Copernicon Theory in Poland in Seventeenth and Nighteenth Centuries
Dobrowolski T.	Les arts a Cracovio aux temps des etudes de Copernic
Dobrzycki J.	Astronomia przedkopernikańska
Długosz	Annales seu Cronicas
Estreicher K.	Pamiętniki Kopernikowskie w Uniw. Jagiellońskim
Estreicher K.	Copernican Relics in Jagiellonian Uniwersity
Estreicher K.	Les souvenirs de Copernic á l'Universite Jagiellone
Galilei G.	Dialog o dwu najważniejszych układach świata Ptolomeuszowym i Kopernikowskim
Górecki K.	Dom i środowisko rodzinne M. Kopernika
	Histoire de Pologne
Iwaniszewska C.	Astronomia Mikołaja Kopernika
pod red. C. Iwaniszewskiej	Astronomia w Toruniu, mieście rodzinnym Mikołaja Kopernika
pod red. C. Iwaniszewskiej	Astronomy in Toruń, Nicolas Copernicus Native Town
Jahn	Lód i zlodowacenie
Jastrzębski L.	Biblioteka Mikołaja Kopernika
Kopernik M.	Opera Omnia t.1 wersja angielska
Kopernik M.	Opera Omnia t.1 wersja łacińska

Kuratowski	Introduction to Set Theory and Topology
Lipiński E.	De Copernic a Stanisław Leszczyński
Łomniewski	Physical Oceanography
	Mała Encyklopedia Powszechna
	Mikołaja Kopernika dzieła wszystkie
Nowak Z.	Kultura umysłowa Prus Królewskich w czasach Kopernika
	Rocznik Toruński t. 7 1972
	Rocznik Toruński t. 8 1973
Rybka E.	Cztery wieki rozwoju myśli Kopernikowskiej
Rybka E.	Four hundred years of the Copernican Heritage
Rymaszewski B.	Toruń w czasach Kopernika
Rymaszewski B.	Toruń in the days of Copernicus
Słabczyński	Polscy podróżnicy i odkrywcy
Stawikowski A.	Wszechświat Kopernika a kosmologia współczesna
	Sztuka Pomorza Zachodniego
Tatarkiewicz	Historiy of Aestheties t. 1
Tatarkiewicz	Sztuka Polska romańska i przedromańska t. 1
Tatarkiewicz	Bionies
Tujakowski A.	M. Kopernika "De Revolutionibus" historia wydań
Voise W.	Mikołaj Kopernik. Dzieje jednego odkrycia
	Zamek Królewski w Warszawie

Zbiorowa	Międzynarodowe powiązania Uniwersytetu Krakowskiego w dobie Kopernika
Zbiorowa	Krakowski krąg Mikołaja Kopernika
Zbiorowa	Gospodarka i budynki Uniw. Jagiellońskiego od XV do XVIII wieku
Zbiorowa	The Cracow Circle of Nicholas Copernicus
	Acta Astronomica
	Acta Biochemica Polonica
	Acta Geologica Polonica
	Acta Geophisica Polonica
	Acta Microbiologica Polonica, Seria A
	Acta Microbiologica Polonica, Seria B
	Acta Palaeontologica Polonica
	Acta Physica Polonica, Seria A
	Acta Physica Polonica, Seria B
	Acta Societatis Botanicorum Polonia
	Archiwum Akustyki
	Archiwum Automatyki i Telemechaniki
	Archiwum Budowy Maszyn
	Archiwum Elektrotechniki
	Archiwum Górnictwa
	Archiwum Hutnictwa
	Archiwum Hydrotechniki
	Archiwum Inżynierii Lądowej
	Archiwum Mechaniki Stosowanej
	Archiwum Procesów Spalania
	Biuletyn PAN Wydz. II, ser.biologia

Biuletyn PAN wydz. III, ser.chem.

Biuletyn PAN Wydz. III, ser.nauki o ziemi

Biuletyn PAN Wydz. III, ser.matem.-fiz.

Biuletyn PAN Wydz. IV, ser. techn.,

Biuletyn Żydowskiego Instytutu Historycznego

Chemia analityczna

Chemia Stosowana

Chrońmy Przyrodę Ojczystą

Control and Cybernatios

Czasopismo Geograficzne

Dydaktyka Szkoły Wyższej

Dziennik Urzędowy MN, SzWiT

Euhemer — Przegląd Religioznawczy

Filomata

Folia Biologica

Folia Histochemica at Cytochemia

Genetica Polonica

Geodezja i Kartografia

Górnictwo Odkrywkowe

International Review of Sport Sociology

Inżynieria Chemiczna

Kosmos ser. "A" - Biologia

Kronika Warszawy

Kultura i Społeczeństwo

Kwartalnik Architektury i Urbanistyki

Kwartalnik Historyczny

Kwartalnik Historii Kultury Materialnej

Kwartalnik Historii Nauki i Techniki

Kwartalnik Neofilologiczny

Kwartalnik Pedagogiczny

M e a n d e r

Mechanika Teoretyczna i Stosowana

Nowości PWN. Biuletyn Informacyjny

N u k l e o n i k a

Orzecznictwo Sądów Polskich i Komisji Arbitrażowych

Podstawy Sterowania

Polimery w Medycynie

Polskie Archiwum Hydrobiologii

Polskie Pismo Entomologiczne

Poradnik Językowy

Postępy Astronomii

Postępy Fizyki

Poznaj Świat

Prakseologia

Proceedings of Vibration Problems

Przegląd Geofizyczny

Przegląd Geograficzny

Przegląd Historyczny

Przegląd Humanistyczny

Przegląd Orientalistyczny

Przegląd Statystyczny

Przegląd Zoologiczny

Rocznik Chemii

Rozprawy Elektrotechniczne

Rozprawy Inżynierskie

Ruch prawniczy, ekonomiczny i socjolog.

Slavia Orientalis

Studia Filozoficzne

Studia Nauk Politycznych

Sowriemiennaja Wyższa Szkoła

T h e R i n g

Wiadomości Botaniczne

Wiadomości Chemiczne

Wiadomości Ekologiczne

Wiadomości Parazytologiczne

Wszechświat

Wychowanie Fizyczne i Sport

Zagadnienia Eksploatacji Maszyn

Życie Szkoły Wyższej

PAŃSTWOWE WYDAWNICTWO
ROLNICZE I LEŚNE"

STATE AGRICULTURE AND
FORESTRY PUBLISHERS

ÉDITIONS AGRICOLES ET
SYLVICOLES NATIONALES

Warszawa, Al.Jerozolimskie 28

Established 1947, up to 1950 known as "PAŃSTWOWY INSTYTUT WYDAWNICTW ROLNICZYCH". Scope of activity: publications on all problems of agriculture and forestry as well as veterinarymedicine, rural building trade, economics and organization of agriculture; dictionaries and ancyclopaedias; scientific studies, popular science books and professional literature; periodicals.

Fondées en 1947 /jusqu'en 1950 "Państwowy Instytut Wydawnictw Rolniczych"/. Domaine d'activité: ouvrages consacrés á tous les domaines de l'agriculture, de la sylviculture, de la médecine vétérinaire, de la construction rurale, de l'économie et de l'organisation de l'agriculture; dictionnaires et encyclopédies; ouvrages scientifiques, de vulgarisation et de spécialisation; revues.

Bielański W.	Rozród zwierząt 1972
Budsławski J.	Zarys chemii mleka 1971
Budsławski J.	Badanie mleka 1972
Drupka St.	Deszczownie i deszczowanie 1972
Greszta J., Morawski S.	Rekultywacja nieużytków poprz. 1972

Grochowski J.	Dendrometria 1973
Grodziński Z.	Anatomia i embriologia ryb 1971
Kanafojski Cz., Karwowski T.	Teoria i konstrukcja maszyn rolniczych T. II 1972
Kchler W., Schnaider Z.	Owady naszych lasów 1972
Marek K.	Choroby drobiu 1972
Mchorille M.	Ceny i dochody w rolnictwie 1972
Pijanowski E.	Zarys chemii i technologii mleczarstwa 1971
Praca zbiorowa	Użytkowanie bydła 1972
Praca zbiorowa	Fizjologia zwierząt 1973
Praca zbiorowa	Produkcja nasion roślin ozdobnych 1972
Stefański W.	Parazytologia weterynaryjna. T.I. Protozoologia i holmintologia. 1968
Stefański W.	T.II. Arachno-ontomologia 1970
Stefański W., Żarnowski E.	Rozpoznawanie inwazji pasożytniczych u zwierząt 1971
Strojny W.	Rośliny chronione w Polsce 1972
Strojny W.	Nasze zwierzęta chronione 1972
Tomczak F.	Rolnictwo Polski Ludowej 1972
Węgorek W.	Nauka o szkodnikach roślin 1972
Zarzycki J.	Histologia zwierząt domowych i człowieka 1971

PAŃSTWOWE ZAKŁADY
WYDAWNICTW SZKOLNYCH

STATE SCHOOLBOOK
PUBLISHING HOUSE

ÉTABLISSEMENTS NATIONAUX
D'ÉDITIONS SCOLAIRES

Warszawa, pl.H.Dąbrowskiego 8

Established 1945. Scope of activity: textbooks for elementary, special and vocational schools /as concerns general education subjects/, for general education secondary schools, adult schools and teachers' colleges; pedagogic and popular science literature; periodicals.

Fondés en 1945. Domaine d'activité: manuels pour les écoles du premier cycle, spéciales et professionnelles /matiéres du programme d'enseignement général/, pour les lycées d'enseignement général, les écoles pour travailleurs et les écoles normales; ouvrages de pédagogie et de vulgarisation scientifique; revues.

Bernasiowie F.i J.	V Kolumna 1972 wyd.I
Burzyński R.	Lidzbark Warmiński 1972 wyd. I
Dominik A., Królikowski K.	Surowce energetyczne Polski 1973 Wyd. I
Dylikowa A.	Geografia Polski, Krainy geograficzne 1973 wyd. I
Eustachiewicz I.	Antologia Literatury powszechnej t.I/II 1973, wyd. II

Gotzman J., Jabłoński B.	Gniazda naszych ptaków 1972, wyd. I
Haykowski M.	Frombork 1973, wyd. I
Kupisiewicz Cz.	Nauczanie programowe 1973 wyd. III
Olszewski T.	Człowiek i jego środowisko 1971 wyd. I
Sokołowski J.	Ptaki polskie 1972 wyd. III
Wawrykowa M.	Między pierwszą a drugą Rzeszą 1972, wyd. I
Woźnicka Z.	Wychowanie estetyczne w przeszkolu 1971 wyd. I
Wrzosek A.	Główne okręgi przemysłowe Polski 1972, wyd. I
Zientara B.	Historia powszechna średniowiecza 1973

PAŃSTWOWY INSTYTUT WYDAWNICZY
STATE PUBLISHING INSTITUTE
INSTITUT NATIONAL D'ÉDITION

Warszawa, ul. Foksal 17

Established 1946. Scope of activity: both classics and contemporary Polish and foreign belles-lettres, essays, plays, drama criticism, theory and history of literature, literary criticism, popular science literature dealing mainly with the history of civilization; periodicals.

Fondée en 1946. Domaine d'activité: littérature classique et contemporaine, polonaise et étrangére, essais, dramaturgie et critique théatrale, histoire et critique littéraires, ouvrages de vulgarisation scientifique principalement consacrés á l'histoire de la culture; revues.

Adamczewski Z.	Tragiczny protest
Andrzejewski A.	Popiół i diament /Bibl. lit. XXX,lecia/
Andrzejewski J.	Trzy opowieści /seria z monogr./
Bielicki M.	Zapomniany świat Sumerów
Brillat A.	Fizjologia Smaku
Brillat A.	Walka o dobra kultury Warszawy 1939-1945 t I/II
Brillat A.	Korespondencja Fr. Chopina z rodziną
Borowski T.	Pożegnanie z Marią. Kamienny świat

Broniewski W.	Wiersze, poematy /Bibl.Lit. XXX-lecia/
Broniewski W.	Wiersze i poematy /wyd. ozdobne/
Czerwiński M.	Przemiany obyczaju
Frankowski K.	Moje wędrówki po obczyźnie t. I/II
Galsworthy J.	Saga rodu Forsyte'ów t.I/II
Galsworthy J.	Nowoczesna Komedia t. I/II
Geremek B.	Życie codzienne w Paryżu w czasach Fr. Villona
Gumilew L.	Dzieje dawnych Turków
Hammend N.G.L.	Dzieje Grecji
Jankowski E.	Eliza Orzeszkowa
Kałużyński Z.	Pożegnanie Molocha
Karniłowiczówna M.	Onegdaj. Opowieść o H.Sienkiewiczu
Kłyś R.	Zabijcie czarną owcę /seria z monogr./
Kochanowski J.	Dzieła polskie /Bibl.Poezji i Prasy/
Kossak E.	Dagny Przybyszewska. Zbłąkana gwiazda
Krasiński Z.	Dzieła Literackie T. I/II
Kruczkowski L.	Dramaty /Bibl.Lit. XXX-lecia/
Krzyżanowski J.	Henryk Sienkiewicz, żywot i sprawy
Kuśniewicz A.	Król obojga Sycylii /seria z monogr./
Kuśniewicz A.	Strefy /seria z monogr./
Lennon H.	Powrót sfinksa
Maleczyńska E.	Życie codzienne Śląska

	Listy do Ottona Forst-Battaglii
	Życie codzienne muzułmanów
	Wyprawy wikingów
	Obrazy Włoch t. I/II
W.	Nagi sąd /seria z monogr./
h J.	Mcnidło
	Świat Księcia Promienistego
	Pisma wszystkie
k E.J.	Był to rok 1945 /Bibl.Lit. XXX-lecia/
i A.	Hrabia Kamil Cavour
	Życie codzienne na Krecie
	F a r a o n
	L a l k a
ski K.	Opowieści /Bibl.Lit. XXX-lecia/
ki Z.	Bogusławski t. I/II
W.S.	Chłopi t. I/II /Bibl.klas.Polski i Obc./
.W.P.	Wielki Upadek Babilonii
wicz H.	Trylogia t. I/IV /wyd. ozdobne/
ewicz H.	Krzyżacy t. I/II /wyd. ozdobne/
ewicz H.	Quo Vadis
ewicz H.	W pustyni i w puszczy
ki J.	Uspokojenie
ki J.	Dramaty /Bibl.Klasyki Polskiej i Obcej/

Suchodolski B.	Labirynty współczesności
Swolkień H.	Robert Schumann
Szenic S.	Maria Kalergis
Szypowska M.	Konopnicka jakiej nie znamy
Targowski A.	Informatyka - klucz do dobrobytu
Teoplitz T.K.	Mieszkańcy masowej wyobraźni
Terlecki W.	Dwie głowy ptaka /seria z monogramem/
Watała E., Woroszylski	Życie Sergiusza Jasienina
Witkiewicz I.S.	Dramaty t. I/II
Wojdowski B.	Chleb rzucony umarłym /seria z monogr./
Żalewski W.	Splot słoneczny /seria z monogr./
Żeleński T. /Boy/	L i s t y
	Listy miłosne Kazimierza Junoszy-Stępowskiego

ZAKŁAD
W LEKARSKICH
Przedsiębiorstwo
one

DICAL PUBLISHERS
STATE ENTERPRISE

MÉDICALES DE POLOGNE
E NATIONALE DISTINCTE

ul.Długa 38/40

ed 1949. Scope of activity: medicine and kindred
hygiene and sanitary education; textbooks for students
upils in secondary medical schools, dictionaries and
; scientific studies and popular science books; scien-
training films for university-level schools and for
medical schools; periodicals.

n 1949. Domaine d'activité: médecine et sciences appa-
hygiéne et éducation sanitaire; manuels universitaires
es éléves des écoles médicales secondaires, dictionna-
ade-mecum; ouvrages scientifiques et de vulgarisation;
entifiques et didactiques pour les écoles médicales
es et secondaires; revues.

ow B.	Intensywna terapia internistyczna
',	Słownik lekarski łacińsko-polski
ki	Podstawy ogólnej diagnostyki w chorobach wewnętrznych

Czerny Z. i inni	Zdrowe i smaczne
Dolatowski A., Ulewicz K.	Zarys fizjopatologii nurkowania 1973
Hausmanowa-Petrusewicz I.	Choroby nerwów obwodowych 1972
Herman E.	Atlas kliniczny chorób układu nerwowego 1973
Karbowski J.	Tęcza nad Solferino 1973
Klonowicz S.	Słownik terminologiczny fizjologii i higieny pracy 1973
Konopka S., Flis	Mikołaj Kopernik
Koszarowski T., Kołakowski A., Lewiński T.	Chirurgia onkologiczna 1973
Kozłowski K., Szczepski O.	Retgenodiagnostyka urologiczna wieku dziecięcego 1972
Koźmiński	Pielęgnowanie zdrowia i urody 1972
Koźmiński	Lexicon Medicum 1971
Leszczyński	Purulent and Fibrous Mediastinitis Radiologica 1972
Orłowski W.J.	Encyklopedia objawów okulistycznych w zespołach układowych 1973
Poradowska	Surgical lung discasee 1972
Rembieliński R., Kuźnicka B.	Historia Farmacji wyd. II 1972
Roszkowski I.	Zdrowie Kobiety 1973
Rzepecki W., Lengera J.	Ropne choroby klatki piersiowej i ich chirurgiczne leczenie 1972
Szapiero	Essays and Studies in Neurosurgery 1972

TYTUT WYDAWNICZY "PAX"

X" PUBLISHING INSTITUTE

TITUT D'ÉDITION "PAX"

rszawa,ul.Mokotowska 43

tablished 1949. Scope of activity: Christian theology and
ilosophy, the humanities /especially the contemporary Polish
story/; belles-lettres.

ndé en 1949. Domaine d'activité: philosophie et théologie
rétienne, sciences humaines /plus particuliérement; histoire
cente de Pologne/; littérature.

elard P.	Pisma teologiczne
gusławska Z.	Pawie pióro
randstastter B.	Jezus z Nazaretu T.I
randstastter B.	Jezus z Nazaretu T.II
randstastter B.	Jezus z Nazaretu T.III
randstastter B.	Jezus z Nazaretu T.IV
obraczyński J.	Klucz mądrości
worzaczek W.	Leliwici Tarnowscy
hrlich L.	"Pisma wybrane Pawła Włodkowica"
razm z Rotterdamu	Pisma moralne
awdzik W.	Ortografia na wesoło

Gawecki B.	Filozofia rozwoju
Gawecki B.	Polscy myśliciele romant.
Gawecki B.	Zagadnienia przyczynowości w fizyce
Jokiel J.	Udział Polaków ...
Kowalewski Z.	Nauki społeczne
Kowalski S.	Pismo św. N. Testamentu
Krokiewicz A.	Zarys filozofii greckiej
Liebert J.	Poezje zebrane
Luijpen W.	Fenomenologia
Pascal B.	M y ś l i
Mroczek A.	Zwycięstwo
Parnicki T.	Staliśmy jak dwa sny
Piechowski J.	Gwiazdy z kraju północy
Praca zbiorowa	Myśl o Teilharda de Chardin w Polsce
Sokretes Scholastyk	Historia Kościoła
Szyszkowska M.	Dociekanie nad prawem natury
Szyszkowska M.	U źródeł współczesnej filozofii prawa
Św.Bazyli Wielki	L i s t y
Teilhard de Chardin	Wybór pism
Wańkowicz N.	Ziele na kraterze
Włodkowic P.	Pisma wybrane T. I/II
Wojewódzki M.	Akcja V1 - V2
Zalewski S.	Czas i istnienie

POLSKIE WYDAWNICTWO
MUZYCZNE
Przedsiębiorstwo Państwowe
Wyodrębnione

POLISH MUSIC PUBLISHERS
DETACHED STATE ENTERPRISE

ÉDITIONS MUSICALES DE POLOGNE
ENTREPRISE NATIONALE DISTINCTE

Kraków, Al.Z.Krasińskiego 11a

Established 1945. Scope of activity: scores and publications on music /especially on ancient and contemporary Polish music/; scholarly studies, popular science books, pedagogical books and textbooks for music schools of all levels, albums.

Fondées en 1945. Domaine d'activité: notes et cahiers de musique, partitions, ouvrages consacrés á la musique /plus particuliérement á la musique polonaise ancienne et moderne/; ouvrages scientifiques et de vulgarisation; ouvrages de pédagogie et manuels pour les écoles de musique de tous les cycles, albums.

Bacewicz G.	Muzyka na smyczki, trąbki i perkusję /mała part./
Baird T.	Psychodrama
Boethoven L.	/ A l b u m /
Chopin F.	Mazurki /Dzieła wszystkie/
Chopin F.	Koncert /złota seria/
Chopin F.	Polonezy /złota seria/

Chopin F.	Preludia /złota seria/
Chopin F.	Ballady /wyd. nar./
Fotek	Cantatina Copernicana w dawnym stylu
Garścia	Graj ze mną na cztery ręce
Górecki	II Symfonia "Kopernikowska"
Górecki	Epitafium /mała part./
Haendel F.	/ A l b u m /
Jarociński	D e b u s s y
Jarzębski	N o v a c a s a
Jeżewski	Rozmowa z Kopernikiem
Koszewski	Nicolao Copernico dedicatum
Lutosławski W.	Melodie Ludowe
Lutosławski W.	B u k o l i k i
Lutosławski W.	Koncert na wiolonczelę
Malawski L.	Miniatury
Moniuszko S.	Pieśni. IV /dzieła wszystkie/
Musica Antiqua Polonica	Średniowiecze
Musica Antiqua Polonica	B a r o k
Muzyka Polskiego Odrodzenia	
Muzyka w dawnym Krakowie	
Penderecki K.	Dies irae
Penderecki K.	Pasja /mała part./
Pękiel	Missaa 14
Raube /red./	Żabki i inne utwory dla dzieci

	Kalejdoskop, wybór utworów /graf. Z.Darowska/
Schäffer	T I S
Serocki K.	Forte e piano
Sobiescy	Polska muzyka ludowa i jej problemy
Szymanowski K.	I Koncert skrzypcowy /Dzieła wszystkie/
Wieniawski	I Koncert skrzypcowy fis-moll /Dzieła wszystkie/
Wroński	Suity i partytury J.S. Bacha
Zieleński	Offertoria I
Zieleński	Salve Regina

BIURO WYDAWNICZO-PROPAGANDOWE
"KSIĄŻKA - PRASA - RUCH"

THE OFFICE FOR EDITING AND
PROPAGANDA "KSIĄŻKA-PRASA-RUCH"

BUREAU D'ÉDITION ET DE PROPAGANDE
"KSIĄŻKA - PRASA - RUCH"

Warszawa, ul.Wilcza 46

Established 1962. Scope of activity: books for children, reproductions of masterpieces of art, postcards, almanachs.

Fondé en 1962. Domaine d'activité: livres pour les enfants, reproduction d'oeuvres d'art, cartes postales, calendriers.

Afanasjew J.A.	Czarodziejski młyn
Afanasjew J.A.	B a ś n i e
Bielicki M.	Chłopiec z glinianą tabliczką
Brandys M.	Najdziwniejsze z miast
Centkiewicz A.	Murti osiołek Laili
Chodorowska W.	Piosenki dla Tomka /wersja niemiecka/
Chotomska W.	Koziołki pana zegarmistrza
Chotomska W.	Siedem księżyców
Czyżewski	Album
Dürer	Album
Ficowski J.	Maciupinka

I.	"O dobrym rycerzu, dumnym koniu i śmiejącym się ośle"
R.M.	Kropla deszczu na dłoni
ska H.	O krakowskim kocie /wersja niemiecka/
ska H.	G r a j m y
ka M.	Trzmiele - wersja holenderska
.	Gdy zakwitną krokusy
J.	Deszczowa muzyka
J.	Wiersze dla Kai
	Kot pięciokrotny
ki T.	Szybciej, wyżej, dalej
	Pamiętniki Zamku Królewskiego w Warszawie
wna J.	Kółko graniaste
awski	Album
J.	Baśń o królu Dardanelu
owa Z.	Przygody Jelonka Pyszałka /wersja czeska/
J.	Ryży placek i 13 zbójców
	Album
wski	Album
lski W.	Czterdzieści szczygłów
uz	Album
	Niobe. Wydanie bibliofilskie
	Wojsko polskie w sztuce współczesnej

WYDAWNICTWO
"SPORT I TURYSTYKA"
Przedsiębiorstwo Państwowe

"SPORT I TURYSTYKA"
PUBLISHERS STATE
ENTERPRISE

ÉDITIONS "SPORT I TURYSTYKA"
ENTREPRISE NATIONALE

Warszawa,H.Rutkowskiego 7/9

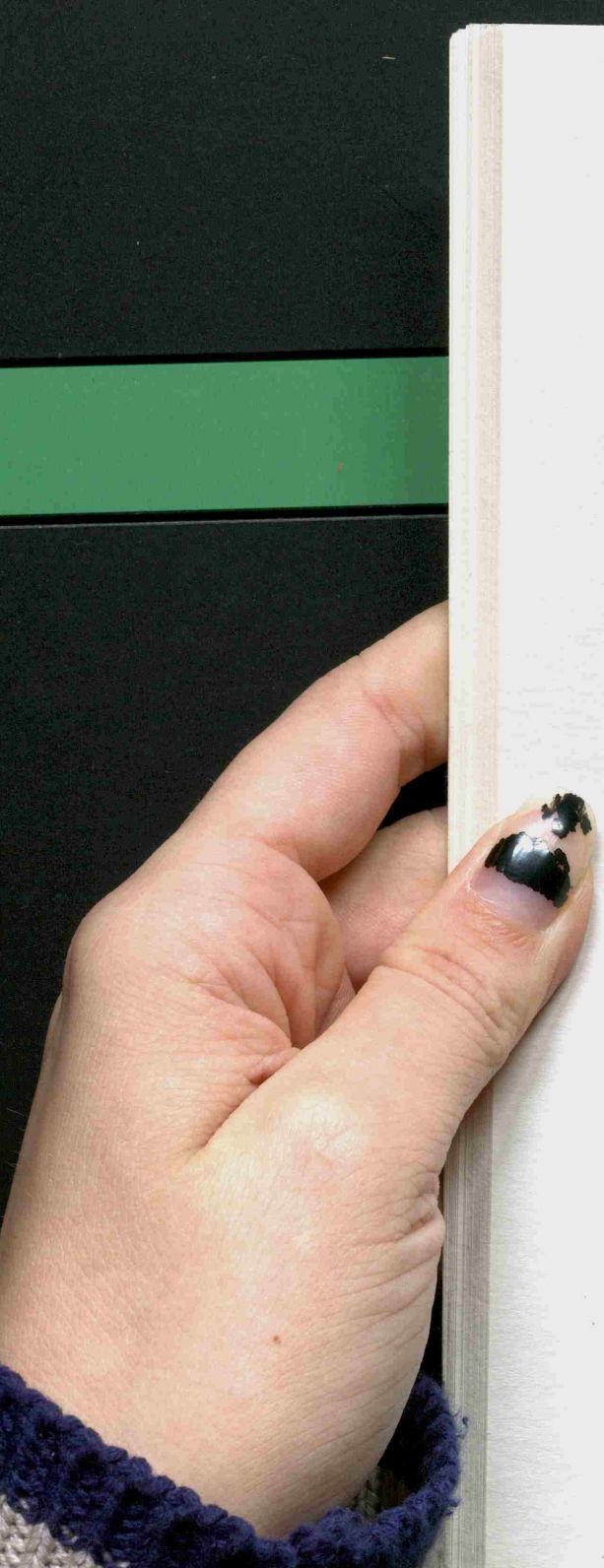
Established 1953. Scope of activity: publications on physical culture, tourism, sightseeing; sport fiction; scholarly studies, textbooks for university-level schools of physical education, professional literature, handbooks, guidebooks, touristic information, albums.

Fondées en 1953. Domaine d'activité: publications consacrées á la culture physique, au tourisme et á la chorographie, littérature sportive; ouvrages scientifiques, manuels pour les écoles supérieures d'education physique, ouvrages de spécialisation, vade-mecum, guides et dépliants touristiques, albums.

Chrzanowski T.	Bystrzyca Kłodzka
Chrzanowski T.	Grudziądz w ang. ros. niem. franc. 1971
Fijałkowski W., Azborski, Jabłoński K.	W i l a n ó w 1973 w.ang. ros. niem. franc.
Gąsiorowscy M.i E.	Toruń 1973 w. angielska

orowscy M.i E.	Toruń 1973 w. niemiecka
cki J.	Z szachami przez wieki i kraje w. angielska 1972
cki J.	Człowiek i hazard w rozlewiskach 1973
anowicz H., l Z.	W dorzeczu Nidy w. franc. niem. ang. ros. 1972
anowicz H.	Nad jeziorami polskich Tatr 1972
zkowski A	Żelazowa Wola 1970
iusz J., ukowski E.	Zielona Góra 1973
ek T., zyński St.	Doły Śląsk 1971
ca zbiorowa	Igrzyska Olimpijskie Monachium 1972
ca zbiorowa	Przewodnik po Polsce w. franc. 1971
ca zbiorowa	Przewodnik po Polsce w.ang. 1971
ca zbiorowa	Kraków 1970 w. angielska
ca zbiorowa	Kraków 1970 w. francuska
ca zbiorowa	Kraków 1969 w.niemiecka
halski W.	Biebrzy i Narwi w. polska 1972
sinek M., lecka M.	Ziemia Kopernika 1973 w. angielska
sinek M., lecka M.	Ziemia Kopernika 1973 w. szwedzka
kowska J.	Warszawa 1972 w. angielska
kowska J.	Warszawa 1972 w. niemiecka
ysse K.Tobiczyk	Tatry 1973 w jęz.franc.niem.ang.ros.

Strojny W.	Włocławek w.ang. ros. niem. franc. 1971
Szypowscy A.i M.	Słupsk w. ang. ros. niem. franc.
Urbański J.	Woliński Park Narodowy 1971
Więcko Z.	W Ostópach Puszczy Białowieskiej 1972



WYDAWNICTWO "ŚLĄSK"
Przedsiębiorstwo Państwowe

"ŚLĄSK" PUBLISHING HOUSE
STATE ENTERPRISE

ÉDITIONS "ŚLĄSK"
ENTREPRISE NATIONALE

Katowice, Armii Czerwonej 51

Established 1954. Up to December,1962 known as "WYDAWNICTWO GÓRNICZO-HUTNICZE". Scope of activity: social and political literature, fiction for adults and youth /with a special stress laid on regional problems/, technical literature on the mining industry and metallurgy; specialist studies and popular science books; periodicals.

Fondées en 1954 /jusqu'en décembre 1962 "WYDAWNICTWO GÓRNICZO-HUTNICZE"/. Domaine d'activité: littérature socio-politique, littérature pour les adultes et les enfants /compte particulièrement tenu des problémes régionaux/, ouvrages techniques du domaine des mines et de la métallurgie; ouvrages de spécialisation et de vulgarisation; revues.

Drzewińska E.	Ziemia Jeleniogórska
Grabski	Nadplastyczność metali
Hierowski Z.	Życie literackie na Śląsku
Honosza N.	Nad twórczością Tomasza Manna
Kracherowa N.	Ziemia Raciborska

Król L., Mazaganek E.	Nowoczesny wielki piec
Krupiński B.	Rodzinne surowce mineralne w gospodarce narodowej Polski
Lubosz B.	Kraina gwarków i lasów
Lubosz B.	Suita Śląska - album
Lubosz B.	Pamiętniki górników
Lubosz B.	Ponad milczeniem i walką. Antologia poezji i satyry powstań śląskich
Mayer J.	Jantaszek z wojny moskiewskiej /druk bibliofilski/
Michałowski M., Wessely R.	Atlas pieców martenowskich
Michałowski M., Wessely R.	Atlas pieców grzewniczych
Morcinek G.	Ziemia Cieszyńska
Morcinek G.	Wyrąbany chodnik
Musioł T.	Dachau 1933 - 1945
Nawrocki W.	O pisarstwie Gustawa Morcinka
Nedoma J.	Wskaźnikowanie rentgenogramów proszkowych substancji tetragonalnych
Paukszta	Warmia i Mazury
Pierzchała J.	Legenda Zagłębia
Pieter J.	Psychologia uczenia się i nauczania
Popiołek K.	Historia Śląska. Od pradziejów do 1945 r.
	Poradnik Górnika. tom 1
	Poradnik Górnika naftowego

Stauba F. Atlas mokrostruktor stali

Trembecki A. Matematyczne metody w górnictwie

Wusatowski Z. Fundamentals of rolling

Zakrzewski B. Tematy śląskie

PAŃSTWOWE WYDAWNICTWO
POPULARNONAUKOWE
"WIEDZA POWSZECHNA "

"WIEDZA POWSZECHNA "
POPULAR SCIENCE STATE
PUBLISHING HOUSE

ÉDITIONS NATIONALES DE
VULGARISATION SCIENTIFIQUE
"WIEDZA POWSZECHNA "

Warszawa, ul. Jasna 26

Established 1952. Scope of activity: popular science books on all branches of knowledge, dictionaries and encyclopaedias, textbooks and teaching aids for study of foreign languages; periodical.

Fondées en 1952. Domaine d'activité: ouvrages de vulgarisation de tous les domaines des sciences, dictionnaires et encyclopédies, manuels et aides pour l'enseignement des langues étrangéres; revue.

Arcimowicz Z.	Czwarty stan materii
Gloger Z.	Encyklopedia staropolska
Jatczak J.	Neutrina kosmiczna
	Kalendarz Kopernikowski 1973
Kielanowski T.	Rozmyślania o przemijaniu
Kompaniejec A.	Prawa fizyki statystycznej
Kotarbiński T.	Abecadło praktyczności

Krzysztofowicz S.	O sztuce ludowej w Polsce
Kuratowski K.	Pół wieku matematyki polskiej 1920-70
Leńkowa A.	Oskalpowana ziemia
	Mały słownik kultury dawnych Słowian
	Mały słownik pisarzy polskich
Michałowski K.	Jak Grecy tworzyli sztukę
Michałowski K.	Nie tylko piramidy
	Polska pierwszych Piastów
	Polska dzielnicowa i Zjednoczona
Pieniążek Sz.	Gdy zakwitną jabłonie. O owocach sadów świata
	Polska w epoce Odrodzenia
	Polska XVII wieku
	Polska w Epoce Oświecenia
Praca zbiorowa	Astronomia popularna
Praca zbiorowa	Człowiek i nauka 1972
Praca zbiorowa	Ziemia /Kompendium Wiedzy/
Praca zbiorowa	Mały słownik matematyczny
Rayski J.	K w a r k i
Reychman J.	Podróżnicy polscy na Bliskim Wschodzie w XIX wieku
Rolbiecki W.	Uniwersytety w Polsce
Rybkowie E.i P.	Kopernik. Człowiek i myśl

Sadurska A. Sztuka ziemi wygasa

Scharf W. Akcelatory cząstek elementarnych

Skubała-Tokarska Z., Tokarski Z. Towarzystwa naukowe w Polsce

Słownik folkloru polskiego

Suchodolski B. Komisja Edukacji Narodowej

Thor J. Kosmonautyka wczoraj i dziś

WYDAWNICTWA ARTYSTYCZNE
I FILMOWE
Przedsiębiorstwo Państwowe

ART AND FILM PUBLISHERS
STATE ENTERPRISE

ÉDITIONS ARTISTIQUES
ET CINÉMATOGRAPHIQUES
ENTREPRISE NATIONALE

Warszawa, ul.Puławska 61

Established 1959. Scope of activity: books and albums on history of art, music, theatre, film and photography; periodicals.

Fondées en 1959. Domaine d'activité: livres et albums consacrés á l'histoire de l'art, á la musique, au théâtre, au cinéma et á la photographie; revues.

Białostocki J.	O sztuce dawnej Ameryki 1972
Degler J.	Witkiewicz w teatrze międzywojennym 1973
Groński R.M.	Od siedmiu kotów do owcy 1971
Grzelecki St.	Twenty Years of Polish Cinema 1970
Janicki St.	Film polski od A do Z 1971
Jewsiewicki Wł.	Polscy filmowcy na frontach Drugiej Wojny Światowej. 1973
Juszczak W.	Postimpresjoniści. 1972
Masłowski M.	Józef Chełmoński 1973
Mroczko T.	Czerwińsk Romański 1972

Praca zbiorowa	Kościoły i klasztory Śródmieścia / z serii Katalog Zabytków Sztuki w Polsce/, 1971 3 tomy
Ryszkiewicz A.	Henryk Rodakowski, 1972
Schiller L.	Podróż teatralna Mickiewicza z Odyńcem, 1973
Secemska K.	Mistrzowie i Książęta. 1972
Toeplitz J.	Nowy film amerykański. 1973
Toeplitz J.	Historia sztuki filmowej 1939-1945, tom V
Twarowska M.	Leon Wyczółkowski, 1973
Machowicz B.	Filmowe przygody małego rycerza
Walicki M., Tomkiewicz Wł.	Malarstwo Polskie. Manieryzm, Barok, 1971
Ważbiński Z.	Renesansowy akt Wenecki. 1972
Ważbiński Z.	Malarstwo Anatterocenta. 1972

WYDAWNICTWA GEOLOGICZNE
PRZEDSIĘBIORSTWO PAŃSTWOWE

GEOLOGICAL PUBLISHERS
STATE ENTERPRISE

ÉDITIONS GÉOLOGIQUES
ENTREPRISE NATIONALE

Warszawa, ul.Rakowiecka 4

Established 1953. Scope of activity: publications on geology; scientific studies and popular science books, textbooks for vocational schools, geological secondary schools and university-level schools, professional literature for geological survey staff; periodicals.

Fondées en 1953. Domaine d'activité: ouvrages géologiques, scientifiques et de vulgarisation, manuels pour les écoles professionnelles du premier cycle, les écoles géologiques secondaires et les écoles supérieures, littérature de spécialisation pour le personnel des services géologiques; revues.

Gruszczyk H.	Nauka o złożach
Jakubowski K.	Skalne zabytki /Album/
Kielan-Jaworowska Z.	Polowanie na dinozaury
Kielan-Jaworowska Z.	Budowa geologiczna Polski - wersja angielska
Kielan-Jaworowska Z.	50 lat działalności Instytutu Geologicznego wersja francuska
Książkiewicz M.	Geologia dynamiczna
Smulikowski K.	Geochemia
	Zarys geofizyki stosowanej

WYDAWNICTWA KOMUNIKACJI
I ŁĄCZNOŚCI

TRANSPORT AND COMMUNICATION
PUBLISHERS

ÉDITIONS DES TRANSPORTS ET
DES TÉLÉCOMMUNICATIONS

Warszawa, Kazimierzowska 52

Established 1949. Scope of activity: publications on transport, /railways, road construction, motor-car transport, aviation/ and communication /mail, wireless, TV/ as concerns technical and economic problems, as well as on meteorology and hydrology; scientific studies, popular science books, reference books; periodicals.

Fondées en 1949. Domaine d'activité: publications relatives aux transports /chemins de fer, construction des routes, automobile, aviation/ et aux télécommunications /poste, radio, télévision/ dans leurs aspects techniques et économiques, ainsi qu'á la météorologie et á l'hydrologie; ouvrages scientifiques et de vulgarisation, vade-mecum; revues.

Burdziński Z.	Teoria ruchu pojazdów gąsienicowych
Dowkontt J.	Teoria silników cieplnych
Kozieł S.	Lotniskowe nawierzchnie betonowe
Luszawski J.	Nawierzchniowe emulsje asfaltowe

Łapiański T., Perkowski Z.	Przewody telekomunikacyjne
Łukomski Z.	Technologia silników spalinowych kolejowych i okrętowych
Miszczak S.	Historia radiofonii i telewizji w Polsce
Nowicki W.	Podstawy teletransmisji, tom I
Piskozup A.	Funkcjonowanie systemów transportowych. Międzynarodowy Rocznik Transportu
Praca zbiorowa	Elektronika medyczna, tom I
Praca zbiorowa	Elementy i układy cyfrowe LOGISTER
Praca zbiorowa	Dziś i jutro telekomunikacji
Rachwal A.	Lotnicze modele wyczynowe
Rychter T.	Karting
Schier W.	Samoloty w historii i miniaturze
Schier W.	Miniaturowe lotnictwo
Schneigert Z.	Koleje niekonwencjonalne
Szczygieł J.	Mosty z betonu zbrojonego i sprężonego
Szelągowski F.	Mosty metalowe, część II
Stankowski J., Graja A.	Wstęp do elektroniki kwantowej
Wiśniewski S.	Obciążenia cieplne silników tłokowych
Wojciechowski J.	Radia-modele. Zasady projektowania i konstrukcji
Wrzesiński T.	Hamowanie pojazdów samochodowych
Zimowski L.	Geneza i rozwój komunikacji pocztowej na ziemiach polskich
Żylicz J.	Międzynarodowy obrót lotniczy

WYDAWNICTWA NAUKOWO-
TECHNICZNE

SCIENTIFIC-TECHNICAL
PUBLISHERS

ÉDITIONS SCIENTIFIQUES
ET TECHNIQUES

Warszawa,ul.Mazowiecka 2/4

Established 1949. Up to 1961 known as "PAŃSTWOWE WYDAWNICTWA TECHNICZNE". Scope of activity; scientific, popular science and technical literature on mathematics, physics, chemistry and chemical industry, light and food industry, electric engineering, electronics, mechanical engineering and machine construction industry, university-level textbooks, encyclopaedias and dictionaries.

Fondées en 1949 /jusqu'en 1961 "Państwowe Wydawnictwa Techniczne". Domaine d'activité: ouvrages scientifiques, de spécialisation et de vulgarisation des domaines suivants: mathématiques, physique, chimie et industrie chimique, industries: textile, du vétement et du cuir, industrie alimentaire, électrotechnique, électronique, mécanique et de construction mécanique; manuels universitaires, ancyclopédies, dictionnaires.

Bańka — Technika a środowisko psychiczne człowieka 1973

Bąbiński — Projektowanie zakładów przemysłowych

	Bibliografia słowników 1969 - 1970
Biestek, Sękowski	Metody badań powłok metalowych 1973
Borkowski	Jednowrzecionowe automaty tokarskie 1972
Broszkiewicz	Chemiczne metody dozymetrii promieniowania jonizującego 1971
Dobrzański	Uchwyty obróbkowe. Poradnik konstruktora 1973
	Encyklopedia Techniki. Automatyka 1972
Felchorski, Stanioch K.	Kalorymetria trójchromatyczna 1973
Frenkler, Zawistowski	Konstrukcja form wtryskowych 1973
Gajewski, Leśkiewicz, Szymanik	Przepływowe silniki odrzutowe 1973
Groszkowski	Technika wysokiej próżni 1972
Hobler	Ruch ciepła i wymienniki, wyd. IV 1971
Janowski	Młody konstruktor 1972
Klamka	Diody mikrofalowe półprzewodnikowe
Konarski, Krysicki	Nomografia i graficzne metody obliczeniowe. Zastosowania w technice
Korzec	Tranzystory polowe 1973
Kratochwil	Technologia wytwarzania maszyn elektrycznych 1973
Litwin, Suski	Technika makrofalowa 1972
Minczewski, Dybczyński Chwastowska	Analiza śladowa 1973
Modrzejewski	Pomiary pił 1971
Mrugalski	Mechanizmy zegarowe 1972

Nowak, Sawicki	Pamięć maszyn cyfrowych 1972
Ochęduszko	Koła zębate 1972
	Poradnik inżyniera. Odlewnictwo 1972
Praca zbiorowa	Analiza polimerów syntetycznych 1971
Praca zbiorowa	Poliwęglany 1971
Praca zbiorowa	Procesy technologiczne w elektronice półprzewodnikowej 1973
Praca zbiorowa	Napowietrzne linie elektroenergetyczne wysokiego napięcia 1973
Praca zbiorowa	Leksykon techniczny Mini - Max 1973
Rosiński	Zasady działania tranzystorów 1973
Seidler	Systemy przesyłania informacji cyfrowych 1972
Selecki	Rozdzielenie mieszanin. Metody niekonwencjonalne 1972
Sękowski	Efektowna chemia 1973
Sękowski	Galwanotechnika domowa 1972
Sękowski, Piaskowski Wojtowicz	Atlas struktur znormalizowanych stopów odlewniczych 1972
Skarzyński, Koterwas Kończykowski	Przewody elektryczne 1973
Skowroński	Elementy dynamiki geometrycznej
	Słownik naukowo-techniczny, angielsko-polski
	Słownik morski, angielsko-polski i polsko-angielski 1968
	Mały słownik techniczny francusko-polski i polsko-francuski. 1972

Troskolański, Łazarkiewicz — Pompy wirowe 1973

Tunia, Winiarski — Układy elektroniczne w automatyce napędowej 1971

Wajand — Trakcyjne silniki z zapłonem samoczynnym 1973

Wejs — Linie pierwiastkowe w automatyce 1973

Zagajewski, Malzacher Kwieciński — Elektronika przemysłowa 1972

WYDAWNICTWO LITERACKIE
Przedsiębiorstwo Państwowe

LITERARY PUBLISHERS
STATE ENTERPRISE

ÉDITIONS LITTÉRAIRES
ENTREPRISE NATIONALE

Kraków, Rynek Główny 25

Established 1953. Scope of activity: contemporary Polish fiction, journalistic writings on home affairs, classics of Polish literature /since mid-19th till the 20th century/, history and theory of literature, literary criticism, history of art, art criticism, aesthetics, scholarly studies and popular science books on Polish history, memoirs /especially from the 19th and 20th century/, translations, literature for children and young people.

Fondées en 1953. Domaine d'activité: littérature polonaise contemporaine, reportages consacrés á la Pologne, classiques polonais /depuis le milieu du XIXe jusqu'au XXe s./, histoire et théorie littéraire, critique littéraire, histoire et critique de l'art, esthétique, ouvrages scientifiques et de vulgarisation consacrés á l'histoire de Pologne, mémoires /principalement des XIXe et XXé siécles/, traductions, livres pour les enfants et la jeunesse.

Bunsch K. Wawelskie wzgórze

Elektrowicz L. Motywy zachodnie

Dąbrowski J.	Z Anglikami na codzień
Figoń	Człowiek i dzieło
Filipowicz K.	Biały ptak
Gołaszewska M.	Zarys estetyki
Hafisz	Pieśni miłosne
Harasymowicz J.	Polska weranda
Heyduk B.	Legendy i opowieści o Krakowie
Ingarden R.	Książeczka o człowieku
Joyce J.	Utwory poetyckie
Kępiński A.	Rytm życia
Kownacka M.	Wesołe przedszkole
Lem S.	Fantastyka i futurologia
Lempicka A.	Wyspiański, idee i formy
Morawski K.	O Kazimierzu Morawskim
Morawski K.	Obraz literatury polskiej XIX i XX wieku
Nowak T.	Takie większe wesele
Pagaczewski S.	Porwanie Baltazara Gąbki
Rzepińska M.	Historia koloru w dziejach malarstwa europejskiego
Szaniawski J.	Profesor Tutka
Świrczyńska A.	Jestem baba
Wyka K.	Makowski

WYDAWNICTWO LUBELSKIE
Przedsiębiorstwo Państwowe

LUBLIN PUBLISHERS
STATE ENTERPRISE

ÉDITIONS DE LUBLIN
ENTREPRISE NATIONALE

Lublin, ul.Okopowa 7

Established 1957. Up to 1961 known as "LUBELSKA SPÓŁDZIELNIA WYDAWNICZA". Scope of activity: social and political literature, memoirs, journalistic writings, essays, Polish fiction /with a special stress laid on regional problems/; periodicals.

Fondées en 1957 /jusqu'en 1961 "Lubelska Spółdzielnia Wydawnicza Domaine d'activité: ouvrages socio-politiques, souvenirs et mémoires, reportages, essais, littérature polonaise /compte particuliérement tenu des questions régionales/; revues.

Zins H. Historia Lublina w zarysie. 1972

Zins H. Logopedia T. 10. 1970

Zins H. Galeria Lubelska. 1970

WYDAWNICTWO MINISTERSTWA OBRONY NARODOWEJ

MINISTRY OF NATIONAL DEFENCE PUBLISHERS

ÉDITIONS DU MINISTÈRE DE LA DÉFENSE NATIONALE

Warszawa, ul.Grzybowska 77

Established 1947. Scope of acticity: scientific and popular science military publications /theory, history, politics, training, education and propaganda/, para-military publications, military encyclopaedias, dictionaries and albums, technical literature on military problems, Polish and foreign fiction, memoirs.

Fondées en 1947. Domaine d'activité: publications militaires et paramilitaires, scientifiques, techniques et de vulgarisation /théoriques, historiques, politiques, d'enseignement et de propagande/, encyclopédies, dictionnaires et albums consacrés à l'art militare, littérature polonaise et étrangére, mémoires et souvenirs.

Biskup M. Trzynastoletnia wojna z Zakonem Krzyżackim 1454-1466, 1967

Błagowieszczeński I. Dzieje I Armii Polskiej w ZSRR /maj-lipiec 1944/, 1972

Buśko B. Vademecum zastosowań elektroniki, 1970

Dzikiewicz B. Topografia, 1971

Lenard B.	Prostowniki stabilizowane 1972
Michalik M.	Moralność a wojna, 1972
Morgała A.	Polskie samoloty wojskowe 1918-1939, 1972
Pachoński J.	Legiony Polskie /prawda i legenda/, tom III - Znad Renu na San Domingo 1799-1802, 1972
Przypkowski T.	Dzieje myśli Kopernikowskiej. 1972
Rzepniewski A.	Obrona Wybrzeża w 1939 r., 1970
Sikorski J.	Zarys historii wojskowości powszechnej do końca XIX w., 1972
Sobczak K.	Wyzwolenie Warszawy. Styczeń 1945, 1970
Sosiński R.	Obrazki ze świata fizyki i techniki
Wróbel T.	Mikromaszyny elektryczne, 1969
Zbiorowe	Wojna polsko-szwedzka 1655-1660, 1973
Zbiorowe	Ruch oporu w Rejencji Katowickiej 1939-1945, 1973
Zbiorowe	Polski czyn zbrojny w II Wojnie Światowej tom VI: Bibliografia wojny wyzwoleńczej narodu polskiego 1939-1945, 1973
Zbiorowe	Polski czyn zbrojny w II Wojnie Światowej, tom III: Ludowe Wojsko Polskie 1943-1945, 1973
Zbiorowe	Historia wojskowości polskiej, 1972
Zbiorowe	Broń CB, stopień zagrożenia, problemy zakazu, 1971
Zbiorowe	Mała Encyklopedia Wojskowa 1969-1971

WYDAWNICTWO MORSKIE
Przedsiębiorstwo Państwowe

MARITIME PUBLISHERS
STATE ENTERPRISE

ÉDITIONS MARITIMES
ENTREPRISE NATIONALE

Gdańsk, ul.Szeroka 38/40

Established 1957. Scope of activity: scientific, popular science and professional literature, social and political literature, fiction-dealing with maritime and sea-coast problems; periodical.

Fondées en 1957. Domaine d'activité: ouvrages scientifiques, de vulgarisation et de spécialisation, ouvrages sociopolitiques et littérature - liés par leur sujet á la mer et au littoral, revue.

Cieślak R., Biernat Cz.	Dzieje Gdańska, 1964
Janion M.	Romantyzm, rewolucja, marksizm, 1972
Ledóchowski A.	Astronawigacja, 1972
Urbanowicz W.	Architektura okrętów, 1965

WYDAWNICTWO POZNAŃSKIE
Przedsiębiorstwo Państwowe

POZNAŃ PUBLISHERS
STATE ENTERPRISE

ÉDITIONS DE POZNAŃ
ENTREPRISE NATIONALE

Poznań, A.Fredry 8

Established 1956. Scope of activity: scholarly and popular science publications on the political and social history of Wielkopolska Region and of Western and Northern Regions of Poland; German question; history of Polish civilization and literature; social and political literature; contemporary Polish and foreign /chiefly German and Scandinavian/ fiction; journalistic writings, memoirs; albums and tourist guidebooks; periodical.

Fondées en 1956. Domaine d'activité: ouvrages scientifiques et de vulgarisation consacrés á l'histoire politique et sociale de la Grande-Pologne ainsi que des provinces occidentales et septentrionales, aux problémes allemands, á l'histoire de la culture et de la littérature polonaises, ouvrages socio-politiques, littérature contemporaine polonaise et étrangére /en premier lieu scandinave et allemande/, reportages, souvenirs, mémoires, albums et guides touristiques, revue.

Choromański M. Zazdrość i medycyna

Chruszczewski Cz.	Rok 10 000
Fiedler A.	Wyspa Robinsona
Jezierski R.	Klasowy charakter moralności
Jezierski R.	Poglądy etyczne Edwarda Abramowskiego
Kogut B.	Misja porucznika Kuny
Krasusski J.	Historia Rzeszy Niemieckiej 1870-1945
Langer T.	Formy państwa socjalistycznego
Paukszta T.	Przejaśnia się niebo, tom I/II
Praca zbiorowa pod red.C.Lebudy	Historia Pomorza, tom I
Szwejkowski Z.	Trylogia Sienkiewicza i inne

ZAKŁAD NARODOWY
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ÉDITIONS DE L'ACADÉMIE POLONAISE DES
SCIENCES

Wrocław, Rynek 9

Established 1817. Scope of activity: the oldest Polish publishing house with a wide profile in the humanities; history of literature, philology, linguistics, history, history of civilization and art, theatre, pedagogics, education, psychology, law, sociology, economics, archaeology ethnography; sources, scholarly studies and popular science books; periodicals.

Fondées en 1817. Domaine d'activité: la plus ancienne officine polonaise d'édition vouern aux sciences humaines dans la plus large acception du mot; histoire de la littérature, philologie, linguistique, histoire, histoire de la culture et des arts, théâtre, pédagogie, éducation, psychologie, droit, sociologie, économie, archéologie, ethnographie; publications de sources, ouvrages scientifiques et de vulgarisation; revues.

Adamski J. Historia literatury francuskiej 1970

Autorzy naszych lektur 1973

Chaciński S.	Wniebogłosy 1973
Chyczewska A.	Marcello Bocciarelli 1973
Conrad-Korzeniowski	Wybór opowiadań 1972
Czapliński-Górski	Historia Danii 1965
Dawid J.W.	Inteligencja, wola i zdolność do pracy
Bogucka M.	Nicholas Copernicus wyd. 1973
Dawski S.	Szkło wrocławskie 1970
Dolaceoix F.	Dzienniki t.I i II 1968
Dezel J.	Historia Rumunii 1970
Dewcy J.	Demokracja i wychowanie 1972
Dewcy J.	Paideia, t.II 1972
Dhim J.	Kościuszko nieznany 1969
Dobrowolski	Nowoczesne malarstwo polskie t.III 1964
Dziubiński A.	Maroko w XVI wieku 1972
Dyczek E.	C i e n i e 1972
	Dydaktyka oświaty politycznej 1973
	Dyktatury w Europie Środkowo-Wschodniej
	Edycje pomnikowe ZN im. Ossolińskich 1973
	Encyklopedia wiedzy o książce 1971
Fałski M.	Fragmenty prac 1973
Felczak W.	Historia Węgier 1966
Fiedor K.	Antypolskie organizacje w Niemczech 1973

Bakes J.	Wołów i Ziemia Wołowska 1972
Bal K.	Rozum i historia wyd. 1973
Balicki	Dyskryminacja rasowa 1972
Bartosz J.	Południk zero 1973
Bazylow L.	Historia Rosji 1969
Bellert J.	On the Logico Semantic 1972
	Biblia królowej Zofii, cz. III 1971
	Bibliografia historii Śląska za lata 1870-1971 1973
	Bibliografia Historii Polski XIX w. t. II cz. 2 1972
	Bibliografia Historii Polskiej za rok 1970-1972 1972
Bieliński B.	Najstraszniejszy życiorys Mikołaja Kopernika. Studia Copernicana, IX 1973
Bieńkowska B.	Kopernik i heliocentryzm. Studia Coper. III
Birkenmajer A.	Etudes. Studia Copernicana, IV 1973
Birkenmajer A.	Etudes. Studia Copernicana, I 1970
Birkenmajer A.	Poland the Land of Copernicus 1973
Biskup M.	Regesta Copernicana. Studia Copernicana VIII wyd. 1973
Bogucka M.	Nicholas Copernicus wyd. 1973
Borkowska-Nowak W.	Początki polskiej psychologii 1973
Braniewski T.	Trzebnica 1973
Brożek M.	Historia literatury łacińskiej 1969
Chaciński S.	Siedem zdarzeń różnych 1973

	Filologia w Polsce. Słownik Pisarzy 1971
Fredro A.	Zemsta "Nasza Biblioteka" wyd. 6 1973
Frankowski B.F.	Chowanna t. I/II 1970
Gała H.	Biały blues. 1972
Gałczyński K.I.	Wybór poezji 1973
Gąsiorowski, Kępisty A.	Przewodnik arch. 1973
Grabowski J.	Ludowe malarstwo na szkle 1969
Grońska M.	Nowoczesny drzeworyt polski III 1971
Górski H.	Mikołaj Kopernik
Hanulanka D.	Świdnica 1973
Hermansdorfer M.	Józef Gielniak 1972
Hesen S.	Filozofia, kultura, wychowanie 1973
Hesen S.	Utopiści XVI i XVII w. o wychowaniu i szkole
	Historia etnografii polskiej 1972
	Historia nauki polskiej t.I/II 1970
Huml I.	Warsztaty Krakowskie 1973
	Inkunabuły w bibliotekach polskich 1971
	Instytucja Prawa Administracyjnego Państw Socjalistycznych Europejskich 1973
	Inteligencja polska XIX i XX w. 1971
Jakimowicz J.	Tomasz Zieliński 1973
Jakimowicz J.	Wiersze wybrane 1972
Jankowski Z.	Wysokie łowisko 1972

Jasieński R.	Utwory poetyckie 1972
Jastrzębski S.	Jawor i okolice 1973
Jodłowski, Tomaszycki	Zasady pisowni
Kaleta R.	Oświeceni i sentymentalni 1971
Kapuścińska S.	Zbroja błękitna 1973
Kepler J.	Tajemnica kosmosu 1972
Kędzierski	Dzieje Anglii 1966
Kiero B.	Ciemny chleb 1973
Kłębowski J.	Nysa 1972
Kleiner J.	Słowacki 1972
Kotarbińska T.	Traktat o dobrej robocie wyd. 1973
Kocot K.	Organizacje Międzynarodowe 1972
Kowalczyk J.	Sebastiano Serlio 1973
Kowalska A.	Conrad 1896-1900 1973
Krasicki I.	Mikołaja Doświadczyńskiego Przypadki B.N. 1973
Krempf Z.	Miedzioryty 1973
Krzyżanowski J.	Neoromantyzm polski 1971
Krzyżanowski J.	Problemy romantyzmu polskiego 1971
Kubicki H.	C a m b i t 1972
Kuczyński A.	Syberyjskie szlaki 1972
Kulaka	Więc jestem 1973
Karyłowicz J.	Studies in semitie 1972

Lenartowicz T.	Wybór poezji 1972
Lermontow M.	Wybór poezji 1972
	Literatura staropolska i jej związki europejskie
Liwiusz	Historia Węgier 1966
Lebman J.	Nad wodami czarnej rzeki 1973
	Ludność dawniej i dziś 1973
Maciejewski S.	Zapamiętywanie nagiej córki 1972
Maciej z Miechowa	Opis Sarmacji 1972
Mamuszka T.	Droga Królewska w Gdańsku 1972
Markowski M.	Burdanim, Studia Copernicana II
	Mediaevalia philosophica Polonorum t.XVI
Mickiewicz A.	Pan Tadeusz 1972
Mickiewicz A.	Dzieła wszystkie t. IV 1969
Mickiewicz A.	Dzieła wszystkie t. I cz. I 1971
Mickiewicz A.	Dzieła wszystkie t. I cz. II 1972
Mikołajek T.	Żarówka 1973
Muszanka D.	Karykatury K. Sichulskiego 1970
	Na olimpijskiej bieżni 1968
Niemcewicz J.U.	Powrót posła, Nasza biblioteka 1973
Nowacki T.	Elementy psychologii 1973
Nowakowska W.	Stanisław Witkiewicz 1970
Olędzki J.	Sztuka Kurpiów 1970
	Onomastica t. XVII z. 1/2 1972

Orski M. — Zmowa obojętnych 1973

Orzechowski S. — Wybór pism 1972

O współczesnej kulturze literackiej t. 1 1973

O współczesnej kulturze literackiej t. II 1973

Pamiętnik Literaccki R.L. IIV zl. 1973

Pasierb B. — Rok pierwszy 1945-1946 1972

Pasterniak S. — Zapamiętywanie nagiej córki 1972

Parandowski J. — Trzy znaki zodiaku 1972

Pauli Z. — Pieśni ludu polskiego w Galicji 1973

Pestalozsi J.H. — Pisma pedagogiczne 1972

Polański K. — Słownik etymologiczny 1973

Pollak E. — "Goffred" 1973

Pollakówna J. — Formiści 1972

Polonia Typographica t. VIII 1972

Polonia Typographica Saeculi Sedecimi 1972

Polska 2000 5/72 1973

Polska 2000 1/72 1972

Polska sztuka ludowa R. XXVI, n r 3 1973

Polski słownik bibliograficzny z. 77 1973

Prawidła poprawnej wymowy polskiej 1973

	Problems of the science 1971
	Problemy literatury staropolskiej s. I
	Problemy literatury polskiej lat 1890-1939 d. I 1972
	Problemy Polonii Zagranicznej VIII 1973
	Problemy literatury Polskiej okresu Oświecenia
	Problemy literatury staropolskiej, seria II
	Problemy Polonii Zagranicznej t, VIII 1973
Przeździecka M.	O Małopolskim malarstwie 1973
Rzeczak S.	Na tropach słów 1973
Redarowa D.	Polski emigracyjny Ośrodek Naukowy we Francji 1972
Reychman J.	Historia Turcji 1973
	Rocznik Historii Sztuki t.IX 1973
	Rocznik Zakładu Narodowego im. Ossolińskich t. VIII 1973
Różewicz T.	Sztuki teatralne 1972
Rudnicka J.	Bibliografia powieści Polskiej 1964
Rzepecki M.W.	Skalpel ma dwa ostrza 1973
Rylska I.	Współczesna grafika wrocławska 1973
Sawoniak H.	Bibliografia bibliografii polskiej 1967
Senft, Więck	Obozy jenieckie 1972
Serczyk W.A.	Piotr I Wielki 1973

Sęp-Szarzyński M. Rytmy albo wiersze 1973

Sidorski D. Zielony ocean 1973

Sierotwiński Słownik terminów literackich 1970

Sierpowski S. Faszyzm we Włoszech 1919-1926 1973

Sikorski F. Ktoś musi unieść 1973

Sieniarska-Czapli cka Filigrany papierni polskich położonych na obszarze Rzeczpospolitej Polskiej 1969

Sitkowski Bochemizmy fonetyczne 1965

Słowacki J. K o r d i a n 1973

Słownik artystów polskich t. I 1971

Słownik łaciny średniowiecznej t. III z 7/25

Słownik polszczyzny XVI w. t. VI 1973

Słownik języka Adama Mickiewicza t. VII 1971

Słownik Staropolski t. VI z. 7/40 1973

Stopa R. Structurs of Bushman 1972

Strzałkowska M. Historia literatury hiszpańskiej 1968

Strzelichowski S. Dwa lata. XII 1942 - X 1944 1972

Studia o Stanisławie Witkiewiczu 1972

Suchodolski S. Mennictwo polskie w XI i XIX w. 1973

Szafer W. Wspomnienia przyrodnika 1973

Szczucki L. W kręgu myślicieli berezyckich wyd. 1972

Szafer W. Wspomnienia przyrodnika 1973

Sztuka interpretacji, t. II 1973

Szwed L. Głosy ze źródła 1973

Szwed L. Punkt zerowy 1973

Szybiak I. Szkolnictwo KEN 1973

Tatarkiewicz W. Filozofia w Polsce. Słownik pisarzy 1971

Tatarkiewicz W. Towards a System of Human Resources ladicators 1972

Teske A. The History of Physica 1972

Trzynadłowski J. Institut National Ossolińskich 1967

Trzynadłowski J. Zakład Narodowy im. Ossolińskich 1967

Turek L. Kultura i rewolucja wyd. 1973

Tuwim J. Wiersze wybrane 1973

Tymieniecki K. Wspomnienia z jesieni 1939 1972

Tymieniecki K. Wśród amerykańskich poetów 1972

Wasilewski T. Historia Bułgarii 1970

W dawnym Rzymie 1969

Wolfke K. Rozwój i kodyfikacja prawa międzynarodowego

Zabielski Przedstawicielstwo polityczne PRL 1973

Zagadnienia naukoznawstwa t. VIII z. 4/32

Zamek Królewski w Warszawie 1973

Zamek Królewski w Warszawie 1972

Zarys dziejów literatury polskiej 1972

Zarys polskiej myśli ekonomiczno-rolniczej do drugiej wojny światowej 1973

Zarys polskiej myśli ekonomiczno-rolniczej do drugiej wojny światowej 1973

Zerwal-Urbanowicz Z. Pęd pustego kwiatu 1973

Zins H. Mikołaj Kopernik, w. angielskiej 1973
Colloquia Copernicana, XI t. 1 1972
Studia Copernicana, V

Zins H. Mikołaj Kopernik 1972

Żeromski S. Syzyfowe prace 1973

Życie kulturalne robotników 1971

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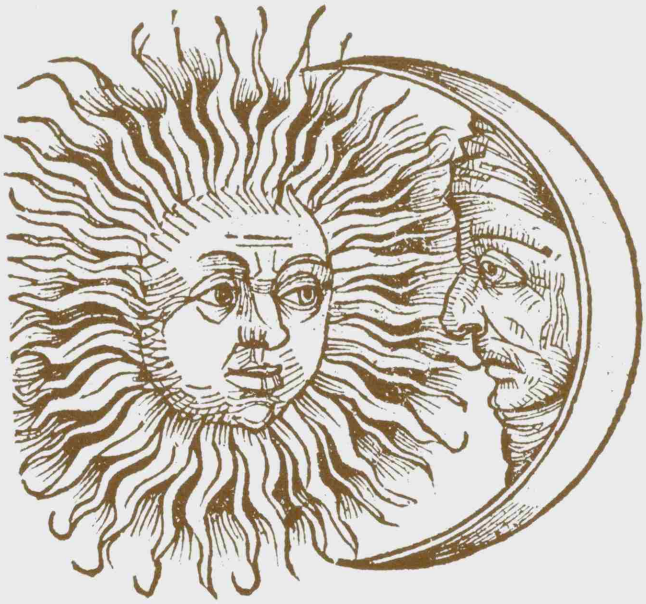
Established 1959. Scope of activity: publications on religious and philosophical subjects, belles-lettres, essays; periodicals.

Fondée en 1959. Domaine d'activité: ouvrages religieux et philosophiques, littérature, essais; revues.

Bartoszewski Wł.	Ten jest z ojczyzny mojej. Polacy z pomocą Żydom 1939-1945, 1966. /materiały dokumentalne/
Cisłowicz J.	Od Kościuszki do Sikorskiego.1971
Górski K.	Matka Mortenska, 1971
Kłoczkowski J.	Wspólnoty chrześcijańskie do wieku XV
Kłoczkowski J.	Kościół w Polsce wiek XVI-XVIII, tom II, 1970
Mamoń Br.	Karol Ludwik Koniński, 1969
Stępień A.B.	Wprowadzenie do metafizyki, 1964



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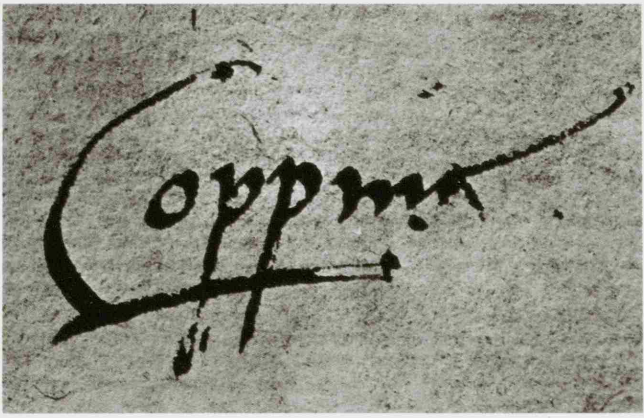


Exhibition designed for IBM by the Office of Charles and Ray Eames
Printed in USA

1450 1475 1500 1525 1550 1575 1600 1625

Copernicus' own life was a secluded one; but during his lifetime Europe entered the age of exploration, the age of the renewal of learning, and of the Reformation.

This chart shows some of his immediate predecessors, contemporaries, and successors. A few — the mathematician Rheticus, the theologian Osiander, and the printer Petreius — affected the Copernican story directly. Tycho Brahe, Kepler, Galileo, and Descartes were the men principally responsible — before Newton — for the assimilation of the Copernican cosmology.

DÜRER 1471-1528 NUREMBURG; BASEL, VENICE

"PAINTER AND GEOMETER"
Albrecht Dürer – a goldsmith's son, like Gutenberg – studied painting, woodcutting and engraving; but like Leonardo he went beyond the disciplines of the hand, to investigate the natural world and the theory of pictorial representation. From his journeys to Italy he brought back new knowledge of perspective and anatomy. He developed the principles of descriptive geometry – based, he said, on the practice of the stonemasons.

DESIDERIUS ERASMUS 1466-1536 GOUDA; PARIS, VENICE, ROME, LONDON, CAMBRIDGE, BASEL

"ERASMUS LAID THE EGG AND LUTHER HATCHED IT"
Erasmus of Rotterdam, first among the independent humanist scholars of the Renaissance, perhaps did more than anyone to encourage the reconsideration of official doctrines in every field of knowledge. His edition of the Greek New Testament put the Latin Vulgate into perspective as a man-made text, second-hand and sometimes inaccurate. It was thanks to Erasmus' editions with the printer Frobenius that there were Greek type-fonts in Basel which were later used for editions in Greek of Euclid's "Elements" and Ptolemy's "Almagest."

MARTIN LUTHER 1483-1546 EISLEBEN; MANSFELD, ERFURT, WITTENBERG

LEADER OF THE PROTESTANT REFORMATION;
seems to have objected to a literally heliocentric universe on religious grounds: "sacred Scripture tells us that Joshua commanded the sun to stand still, and not the earth" (Table Talk, 1539). But teachers at Lutheran universities nevertheless took a leading part in bringing Copernicus' views before the world.

JOHANNES PETREIUS 1497-1550 LANGENDORF; WITTENBERG, NUREMBERG

PRINTER OF THE "DE REVOLUTIONIBUS"
Petreius' printing-shop in Nürenberg was one of the leading scientific publishing houses in Northern Europe, with capacity for very high-grade block-cutting so that elaborate illustrations could be reproduced. Regiomontanus' great collection of astronomical books, manuscripts and instruments was left as a legacy to the Senate of Nüremberg, and the scholars and printers of the city were able to draw on them. Petreius printed a great deal of this material, edited by Johann Schöner.

GEORG RHETICUS 1514-1576 FELDKIRCH; ZURICH, NUREMBERG, TUBINGEN, WITTENBERG, LEIPZIG

PROFESSOR OF MATHEMATICS AT WITTENBERG
Without the intervention of Rheticus, the "De Revolutionibus" would never have got into print. After weeks of discussing the manuscript with the author, Rheticus wrote a "First Report" on its contents. This "Narratio Prima" – the first printed account of the Copernican innovations – was published at Danzig in 1540, with Copernicus' approval. And it was Rheticus who later persuaded the master to let him take the "De Revolutionibus" itself to be printed at Nuremberg.

ANDREAS OSIANDER 1498-1552 GUNZENHAUSEN; LEIPZIG, NUREMBERG, KONIGSBERG

LUTHERAN THEOLOGIAN
As one of the editors in the printing-house of Petreius in Nüremberg, Osiander saw the first edition of Copernicus' "De Revolutionibus" through the press, and added an anonymous preface suggesting that the motion of the earth should be taken as a computational convenience, not as a physical hypothesis. After Copernicus' death Petreius was attacked by Copernicus' friends for printing this preface; he defended it as a necessary compromise to avoid trouble with local Protestant theologians.

JOHANNES REGIOMONTANUS 1436-1476 KONIGSBERG; VIENNA, NUREMBERG, ROME

THE FIRST SCIENTIFIC PUBLISHER
as well as founder of the first European observatory. He was dedicated to carrying on Peurbach's vision – the advancement of astronomy by new observations, combined with fresh analysis of ancient texts – and to collecting and publishing all available astronomical material, so as to hasten improvements.

JOHANN GUTENBERG 1398-1468 MAINZ; STRASSBURG, MAINZ

In Europe Gutenberg's shop seems to have been the first to use movable cast type, in the 1440's. Within thirty years there were printing presses all over Europe.

GEORG PEURBACH 1423-1461 PEURBACH; VIENNA

Peurbach's "New Theory of the Planets" attempted to reconcile Ptolemy's system with Aristotle's. His pupil Regiomontanus continued his work.

JOHANN SCHONER 1477-1547 KARLSTADT; ERFURT, NUREMBERG

ASTRONOMER AND CARTOGRAPHER
Rheticus dedicated his "Narratio Prima" to Schöner, from whom he most probably learned about Copernicus' unpublished work. Schöner was the editor principally responsible for working up the legacy of Regiomontanus manuscripts for printing by Petreius. He also prepared revised astronomical tables.

ERASMUS REINHOLD 1511-1553 SAALFELD; WITTENBERG, SAALFELD

MATHEMATICIAN AND ASTRONOMER
Erasmus Reinhold, professor at Wittenberg at the same time as Rheticus, devised the "Prutenic Tables," based on the tables of planetary position computed by Copernicus, but more convenient in use. He also wrote a commentary on Peurbach's "New Theory of the Planets."

NICHOLAS COPERNICUS 1473-1543 TORUN; KRAKOW, BOLOGNA, PADUA, FROMBORK

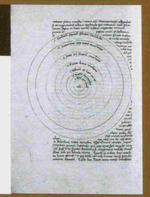
Youngest child of four, son of a prominent merchant, Nicholas Copernicus lost his father at age ten and was adopted by his uncle. He studied geometry at Krakow, Greek at Bologna, medicine at Padua, and became Doctor of Canon Law at Ferrara in 1503. In his twenties he was elected a canon of Warmia, in Prussian Poland, and he retained this position until his death; he never married.

Copernicus used his medical skill to help the poor, and his self-portrait showed him holding a lily of the valley, symbol of the healing art. Although his native language was German he was a loyal subject of the Polish kings, and shared in the defense of his homeland, Warmia, against the Knights of the Teutonic Order. He lectured on mathematics at Rome, criticized an astronomical publication, and made the first Greek-to-Latin translation to be printed in Poland. His treatise on coinage includes an important law later ascribed to Gresham.

Shortly after 1508 Copernicus wrote a brief commentary on astronomy which contained the sentence: "What appear to us as motions of the sun arise not from its motion but from motion of the earth." This theme occupied him for the next thirty years. Although his astronomical work was much admired, and was approved by a restricted circle of friends, he published his *De Revolutionibus* reluctantly, and saw the first printed copy only on his deathbed.

Ptolemy had treated each planet separately; Copernicus brought the earth, sun, moon and planets into an interconnected mathematical system, by giving the earth an orbit which affected the apparent motion of the other heavenly bodies.

The originality and persuasiveness of this massive innovation could only be assessed by those who could follow its mathematics. But through the work of Kepler, Galileo, and Newton, the Copernican system gradually became accepted as the true account of the solar system.



NICHOLAS OF CUSA 1401-1464 TREVES; PADUA, LIEGE, GERMANY

This German Cardinal and astronomer was the first to make the relativist point that our picture of the universe depends on our location as observers, and that the view from the earth has no special claim to the truth.

CHRISTOPHER COLUMBUS 1451-1506 GENOA; PAVIA, GENOA, LISBON, HUELVA

NAVIGATOR
Foremost among the great navigators who stretched the known world to cover more of the terrestrial sphere, Columbus started with severely inaccurate data: he underestimated the circumference of the earth, and overestimated the size of the continent of Asia, and projected his westward journey to the Far East on these assumptions. His Atlantic crossing showed how compass North diverges from North by the Pole Star as longitude changes.

GIROLAMO CARDANO 1501-1576 PAVIA; PADUA, MILAN, BOLOGNA, ROME

ASTROLOGER AND MATHEMATICIAN
Cardano's book "On the Game of Dice" (he was a systematic gambler) marks the beginning of probability theory; and his "Ars Magna" (published by Petreius) is one of the most important treatises on algebra ever written. His interest in astronomy was astrologically oriented; but his star tables were widely quoted by astronomers.

TYCHO BRAHE 1546-1601 KNUDSTRUP; COPENHAGEN, HVEEN, PRAGUE

Tycho Brahe studied philosophy and rhetoric at Copenhagen; but the total solar eclipse of 1560, occurring exactly as the astronomers predicted, impressed him with astronomy as "something divine"; he began systematic observations of his own while still officially studying law. Frederick II, King of Denmark, provided him with an income and a magnificent observatory, Uraniborg; and for twenty-one years, with improved instruments of his own design, Tycho accumulated observations ten times more accurate than any that had been available before. But he died before he could complete his theoretical work; Kepler inherited his observations and edited his principal treatise for publication.

MICHAEL MAESTLIN 1550-1631 GROPPINGEN; TUBINGEN

ASTRONOMER
Michael Maestlin was professor of astronomy at Tubingen. His study of the comet of 1577 convinced him that its motion could best be accounted for in a Copernican scheme. Although he may not have regarded the heliocentric system as more than a computational expedient, he taught his pupils – who included Kepler – about it.

JOHANNES KEPLER 1571-1630 WEIL; GRATZ, PRAGUE, RATISBON

Kepler was responsible for the first creative work on the heliocentric idea after Copernicus himself. Drawing on Tycho Brahe's enormously improved observations, Kepler found that the discrepancies between observed and predicted orbits had certain regularities; and he saw that these could be accounted for if the orbits were slightly elliptical.

His three laws of planetary motion provided the rules for such elliptical orbits, and thus brought prediction in line with observation.

GALILEO GALILEI 1564-1642 PISA; PADUA, FLORENCE

Galileo's principal theoretical contribution to astronomy lies in the study of projectile motion. But equally influential were the observations made possible by his telescope. An ardent Copernican, Galileo presented his discoveries as empirical evidence that the heliocentric system corresponded to physical reality – that the earth really does move; he forced the cosmological issue and incurred the condemnation of the Papal Curia.

RENE DESCARTES 1596-1650

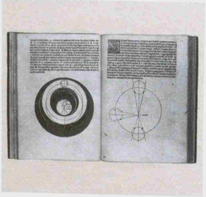
Descartes made essential contributions to the physics that was needed to back up the Copernican cosmology. He made the first clear statement of inertial motion in a straight line; and he recognized that if a planet moves in a closed orbit, it must be deflected inwards by the same kind of force which makes objects fall to the earth.

GIORDANO BRUNO 1548-1600 NOLA; NAPLES, GENEVA, PARIS, LONDON, WITTENBERG, VENICE

DOMINICAN MONK,
was an intelligent defender of the Copernican as against the Ptolemaic world-system. Unlike Copernicus, he definitely asserted the *infinity* of the universe – "thus the earth no more than any other world is at the center." It was not for his cosmological views, however, that he was burned at the stake.

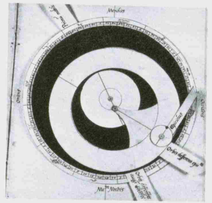
1450 1475 1500 1525 1550 1575 1600 1625

Some 500 years after Aristotle, Claudius Ptolemy of Alexandria developed a working mathematical model by which the positions of the planets could be accurately predicted. Astronomers used Ptolemy's mathematical model for their calculations for fourteen centuries.

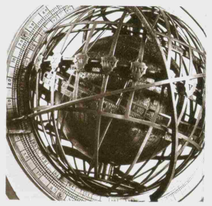


When Columbus landed in America in 1492, Copernicus was a student at the Jagiellonian University in Krakow; and during his lifetime Magellan's expedition rounded the world. The new celestial investigations were part of the Age of Exploration.

In order to explain and systematize their observations of the heavenly motions, the ancient Greek philosophers advanced many different models of the universe. Aristotle's earth-centered model (c. 350 B.C.) was so comprehensive that it persisted for nearly nineteen centuries.

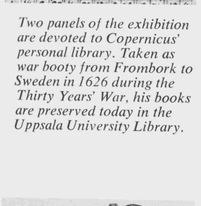


There are two medieval Ptolemy-based astronomy texts in the exhibition. Copernicus first learned astronomy from books based on the Ptolemaic geocentric world model; it was not until later that he acquired a copy of Ptolemy's own book, the Almagest.

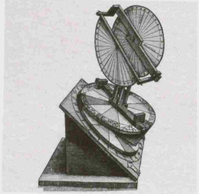


As a student, Copernicus followed the standard medieval curriculum, inherited from Roman educational practice: the trivium — grammar, dialectic, rhetoric — and the quadrivium — arithmetic, music, geometry, and astronomy.

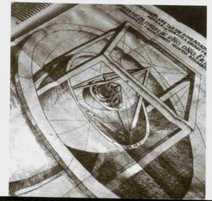
The first European astronomical tables were based on Greco-Arabic knowledge, carried into Europe by the Moorish conquest of Spain. Copernicus used a 1492 printed edition of the Alfonsine Tables; *a copy of this edition figures in the exhibition.*



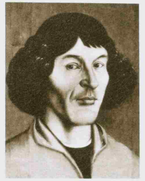
Two panels of the exhibition are devoted to Copernicus' personal library. Taken as war booty from Frombork to Sweden in 1626 during the Thirty Years' War, his books are preserved today in the Uppsala University Library.



Early in the sixteenth century paper astronomical instruments with movable parts appeared in printed books. On display in the exhibition is a 1540 book containing several of these devices.



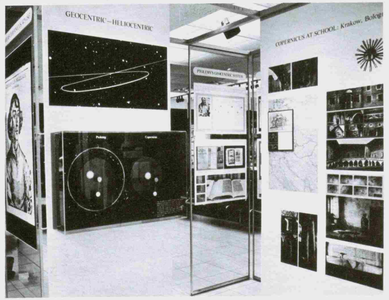
The Copernican system was not generally accepted until the seventeenth century. Kepler, working with Tycho Brahe's precise data, found new laws governing the motions of the planets; Galileo used his telescope to challenge the ancient physics; and finally, Newton established the Law of Universal Gravitation.



NICHOLAS COPERNICUS

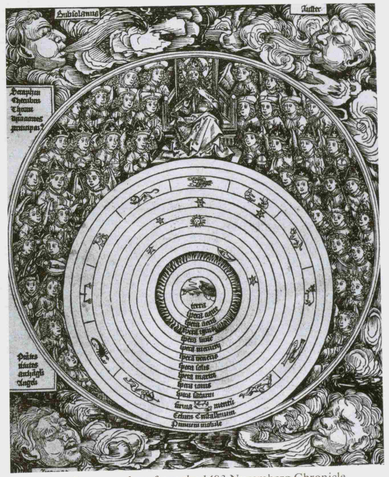
Copernicus was born on February 19, 1473, in Torun, Polish Prussia, the son of a merchant. Though today he is remembered as the father of modern astronomy, in his own time he made his livelihood not as an astronomer, but as an ecclesiastic. His position as canon of the cathedral of Frombork gave him both financial security and freedom to pursue his own astronomical studies. It was at Frombork that Copernicus worked out his great book, the De Revolutionibus.

Two views of the exhibition. The one below shows a working model that demonstrates how two systems—the Ptolemaic and the Copernican—can account differently for the same observed celestial phenomena.



The interior of the Frombork Cathedral.

A GEOCENTRIC SYSTEM



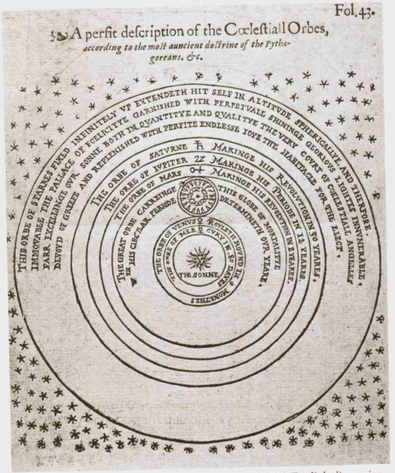
An Aristotelian cosmology from the 1493 Nuremberg Chronicle, *showing the earth, water, air, and fire at the center of the universe.*

The accepted model of the structure of the universe in Copernicus' time was earth-centered. The sun, the moon, the five known planets, and the stars were thought to revolve about the earth in endless, perfect circles.

The model was developed by Aristotle around 350 B.C., and elaborated by Claudius Ptolemy of Alexandria around 150 A.D. Ptolemy outlined his system in a treatise which has come to be known as the Almagest, *meaning "the greatest." What Ptolemy established for the first time was a working mathematical model by which the positions of the planets could be predicted accurately.*

In the Ptolemaic system, each planet moved in a small circle (or epicycle) whose center was carried round the earth in a larger orbit (or deferent). For fourteen centuries astronomers computed planetary positions from tables based on this analysis.

A HELIOCENTRIC SYSTEM



A Copernican cosmology from Thomas Digges' 1576 English discussion of the heliocentric theory, showing the stars scattered in infinite space.

Copernicus described an unfamiliar universe, with the sun, not the earth, at its center; he treated the earth as a planet among the other planets, with a yearly orbit around the sun, a daily rotation on its axis, and a conical precession.

His great breakthrough is the recognition that the complex paths which we see traced by the planets could be explained by a combination of their own motion and that of the earth from which we observe them.

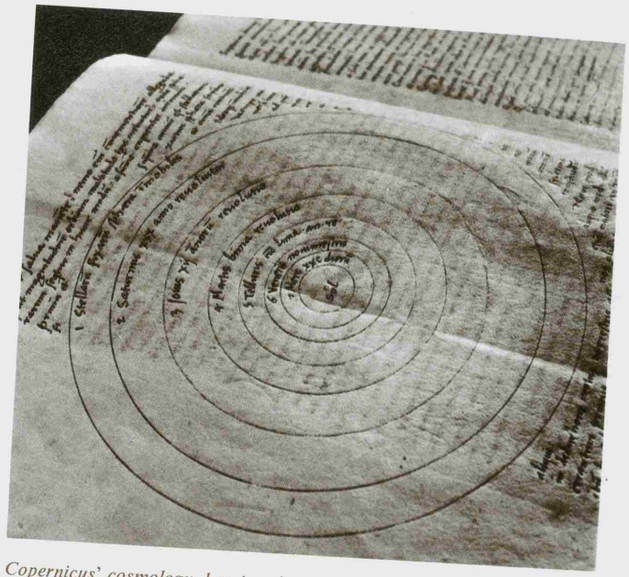
His new model gave astronomical inquiry the direction it still follows today. But he arrived at innovations using the traditional assumption, s by Aristotle and Ptolemy, that the motion of heavenly bodies must be a compound of circles idea which was soon to be overthrown by Johan Kepler, as he worked to build a foundation for th Copernican hypothesis.

AN EXHIBITION CELEBRATING THE 500th ANNIVERSARY OF HIS BIRTH

Nicholas Copernicus was a learned, modest, and conscientious man. Never a priest, he spent his life in service to the cathedral chapter at Frombork, where he was administrator, legal adviser and physician.

But from youth his mind dwelt on the heavens. He was an undergraduate in the cloisters of Krakow University when Columbus set sail across the Atlantic. Before the first ship sailed around the world, Copernicus too had made a pioneering voyage—a voyage of the mind that set the earth itself forever in motion. "We revolve about the Sun like any other planet," he wrote; "the appearance of daily revolutions belongs to the heavens, but the reality belongs to the Earth."

THE *DE REVOLUTIONIBUS*



Copernicus' cosmology drawing, from his manuscript of the De Revolutionibus.

Copernicus' book, the De Revolutionibus, *had an immediate impact on astronomical theory. "Astronomy is written for astronomers," he wrote in his preface. But in the coming century his re-examination of the structure of the universe would permanently alter the way people thought of themselves and their world.*

The De Revolutionibus*—published only in the year of its author's death—might never have appeared in print if Georg Joachim Rheticus, a young professor of mathematics, had not persuaded Copernicus to entrust him with the manuscript for publication.*

CONCERNING THE REVOLUTIONS

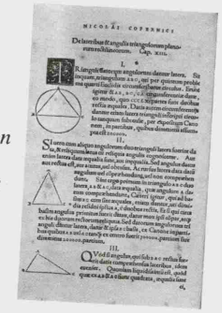
Copernicus patterned the De Revolutionibus *after the structure of Ptolemy's* Almagest.

A NEW COSMOLOGY

Copernicus arranged the planets in a sun-centered system.

A MATHEMATICAL HANDBOOK

He wrote an introduction to trigonometry and included convenient sine tables.



STAR TABLES

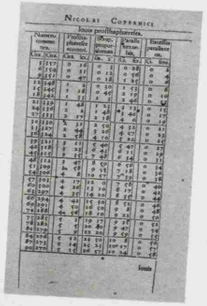
In the Copernican system the sphere of the stars, which serves as reference frame for the motions of the planets, is fixed.

THE THREEFOLD MOTION OF THE EARTH

Copernicus introduced ingenious schemes for the earth's daily, annual, and precessional motions.

THE THEORY OF PLANETARY MOTION

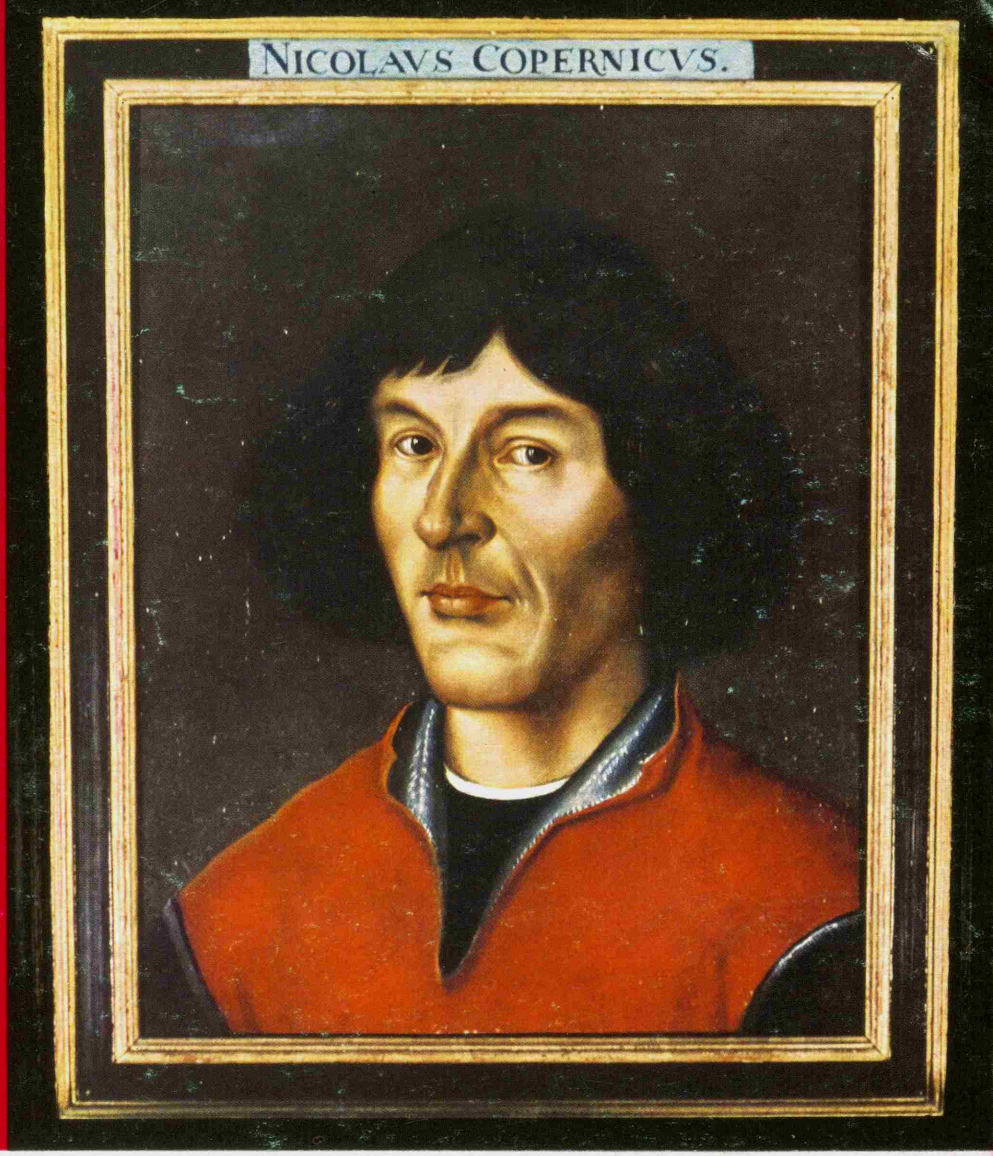
He objected to the Ptolemaic equant, replacing it with an epicyclet.



PLANETARY TABLES

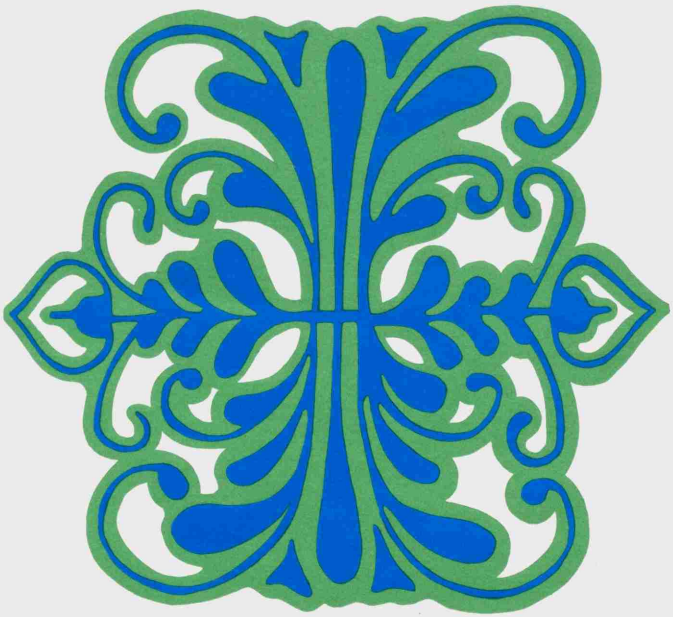
Copernicus included tables for predicting the positions of the sun, moon, and planets at any time in the past or future.

Visit Poland



POLAND

THE HOME OF COPERNICUS INVITES YOU



HISTORY

Once you are in Poland and visiting Warmia, it is certainly worth your while to learn something about the stormy history of this land which has struggled for centuries against a Germanization drive and remained faithful to Poland.

The Order of Teutonic Knights, brought in to Poland in 1226 by Duke Conrad of Masovia, received the Chełmno Land in return for the promise to help defend the frontiert against the Prussians, a pagan Baltic tribe. The Teutonic Order ruled over this land with sword and an iron fist, and the knights became notorious for their cruelty and boundless rapacity. They expanded their state at the expense of Prussian, Polish, and Lithuanian lands and were feared all along the Baltic coast.

In the face of the systematic conquests of Prussian lands, the Holy See divided those areas into three dioceses and proclaimed its supreme authority over them. One of these dioceses was the Warmia diocese whose bishop resided in Lidzbark Warmiński.

The Knights installed members of the Order in bishoprics within their state. Warmia alone resisted this, and only its first bishop, Anzelm, was a member of the Teutonic Order. When the liberation struggle against the Teutonic Order grew in intensity, Warmia refused obedience to the Knights and turned to Poland. The long struggle ended in a formal incorporation of this land into the Kingdom of Poland, confirmed by the Second Peace of Toruń in 1466.

After many defeats suffered in its wars of conquest, the Teutonic Order was finally dissolved in 1525, when the Grand Master Albrecht Hohenzollern embraced the protestant religion and as a lay duke swore allegiance to the Polish King Sigismund I (the Old). Authority in Warmia, where canon Nicolaus Copernicus held numerous responsible posts and offices, was exercised by the bishop residing in Lidzbark Warmiński.

During the First Partition of Poland in 1772, Warmia was seized by Prussia; throughout its rule Prussia made every effort to Germanize the Poles, and did not hesitate to resort to the severest repressions. Thanks to the exceptional fortitude of the population, this policy has never succeeded, even when Hitler came to power and the persecution of Polish patriots was marked by extreme cruelty.

In 1945, when Poland regained independence, Warmia was reunited with her for ever.

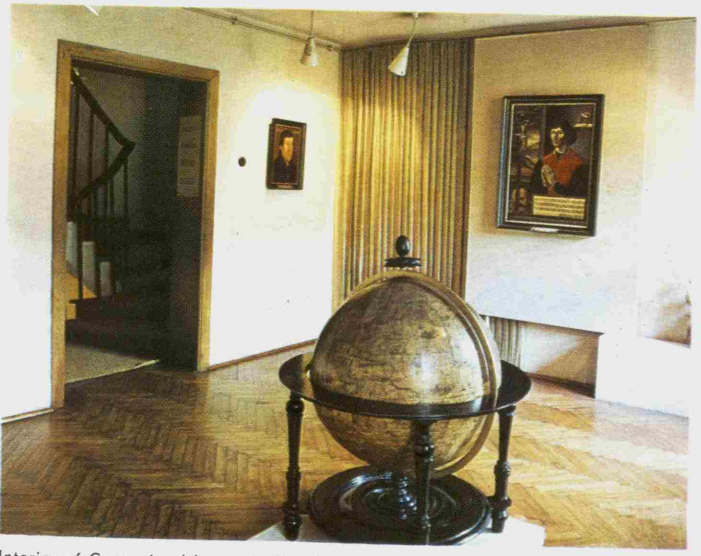
remained nevertheless the city itself is there, with its squares, streets, beautiful old houses, the house in which he was born, the baptismal font in the church of St John, and the magnificent town hall where Copernicus' father was a member of the bench.

What must a tourist see in Toruń? First of all, the Gothic house where Copernicus was born—today a branch of the Regional Museum. Next, the church of St John from the 13th/14th century (reconstructed in the 15th century), where apart from the baptismal font there is a commemorative plaque with the face of Copernicus engraved on it, founded in 1580 by a local doctor, Melchior Pyrnesius. Below the plaque is a marble bust the great astronomer, carved by the Cracovian sculptor W. Rogowski and commissioned by A. Jabłonowski in 1766.

The splendid Gothic and Renaissance town hall stands in the Old Town Square, which was once an administrative, commercial, and official centre of the city. The interesting collections of the Regional Museum include a gallery of burghers' portraits, among them one of Nicolaus Copernicus who probably sat for it himself. The Toruń town hall, after painstaking restoration, still charms the visitors. In front of the town hall stands a monument to the great astronomer.

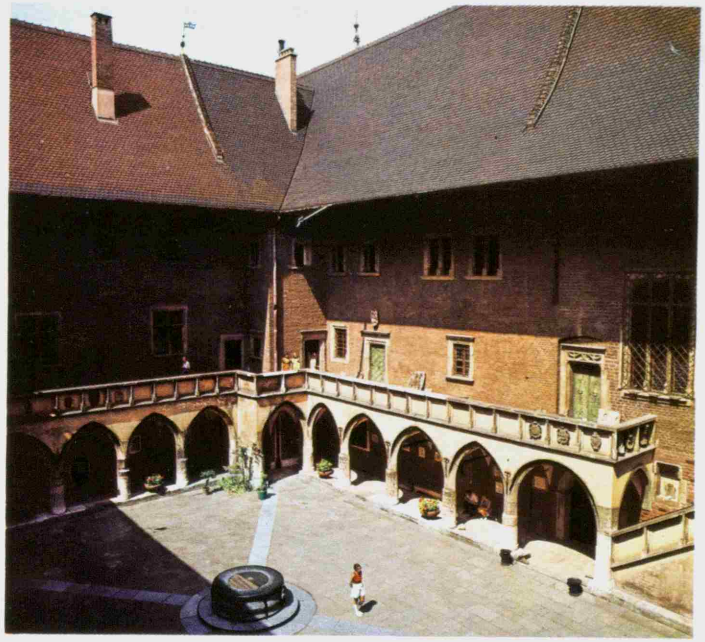
A walk around old Toruń takes us to the place where the imposing castle of the Teutonic Knights once stood. When in 1454, a revolt against the Knights broke out, the people of Toruń stormed the castle and destroyed it, and a resolution of the town council forbid its reconstruction forever. For centuries an enormous artificially made hill covered the ruins of the castle. In recent years the ruins were uncovered and are now accessible to visitors.

Astronomic observatory of the Copernicus University at Piwnice near Toruń has advanced research equipment.



Interior of Copernicus' house in Toruń – branch of Regional Museum.

Period houses in Toruń marketplace.



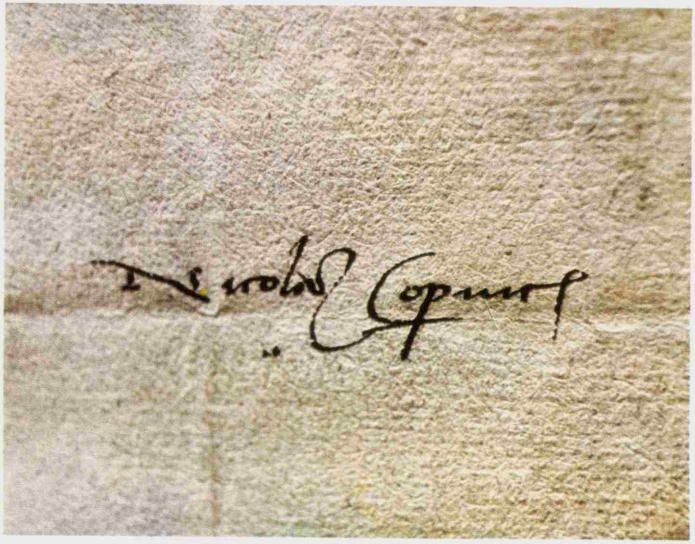
Copernicus studied in the renowned Cracow university from 1491 to 1495. Pictured here is the courtyard of Collegium Maius.

CRACOW

The place of importance in Copernicus' life was Cracow, then the capital of Poland, a cultural and learned centre of this part of Europe, a town no one tracing Copernicus' path should miss. There he studied in the famous Cracow University (known as the Jagellonian University from the 17th century onwards) from 1491 to 1495, at a peak in the history of this school which had then no fewer than 3,215 students.

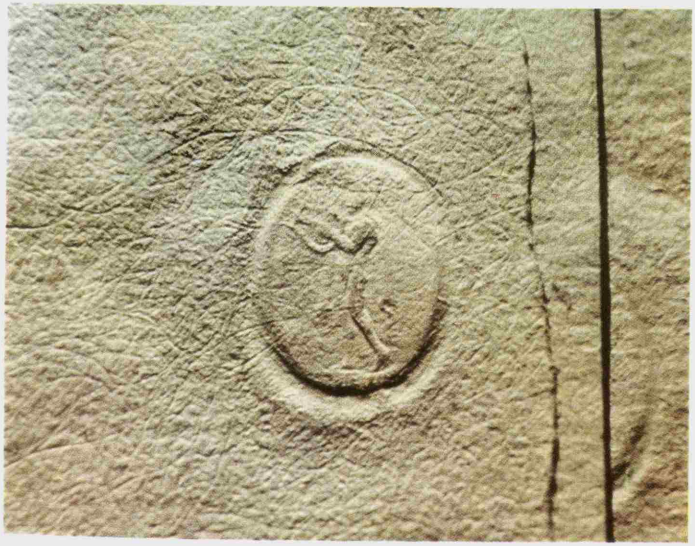
In the autum of 1491, Copernicus made his entry in the Album Studiosorum, a book carefully preserved to this day.

In this University, which can boast of particular achievements in astronomy, the young Copernicus learned all that could be learned then about the skies.



Copernicus' own signature on a 1536 letter kept in Cracow's Czartoryski Library.

"Orbis-Cracovia" Hotel offers comfortable accommodation and the excellent Polish cuisine.



Seal with Apollo with which Copernicus stamped his letters can be seen in Czartoryski Museum in Cracow.

LIDZBARK WARMIŃSKI

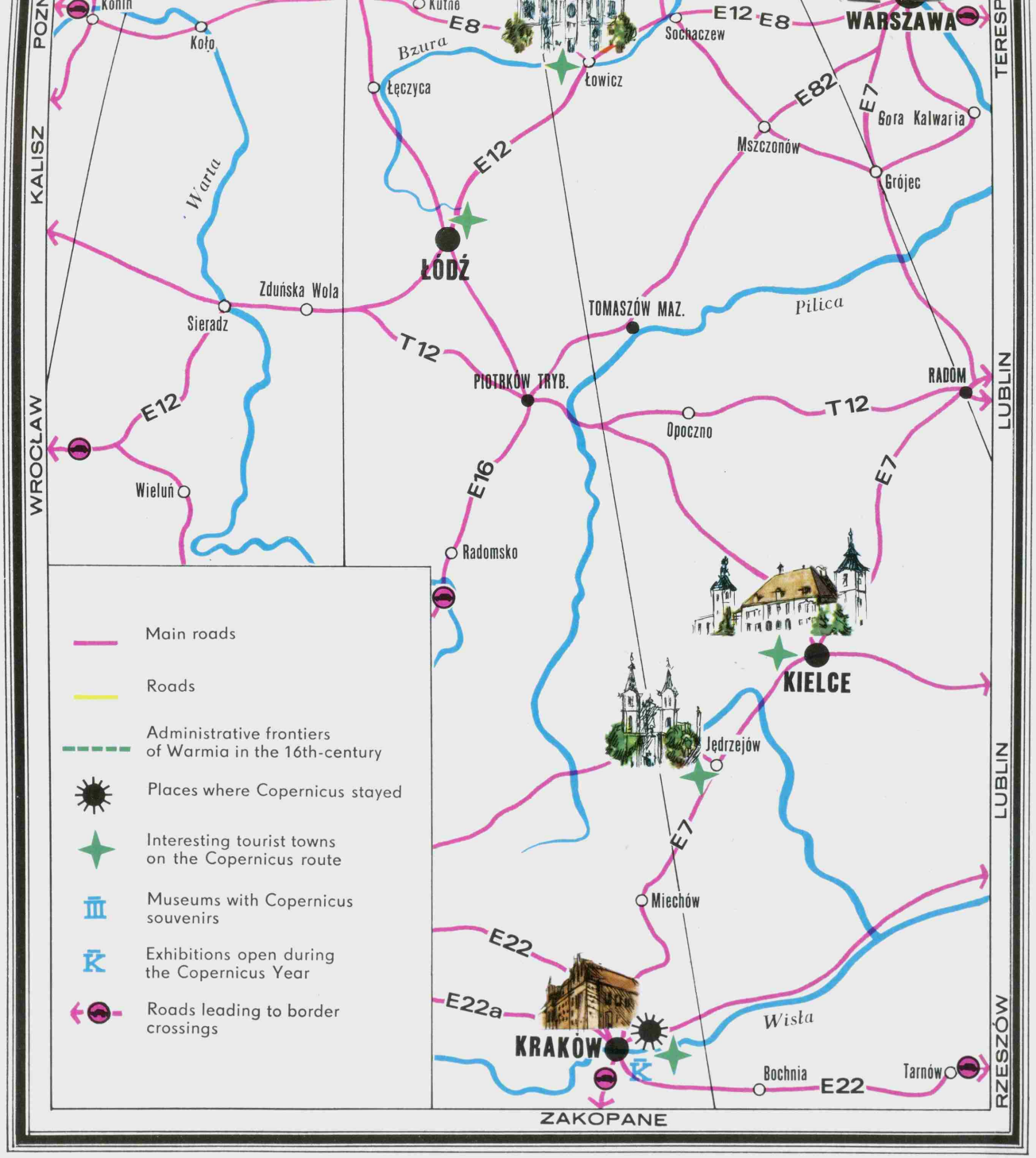
In 1503, after completing further studies in Italy, namely in Bologna, Padua and Ferrara, the 30-year-old doctor of law returned to Warmia and began to work in Lidzbark, a town picturesquely located in the fork of the rivers Łyna and Symsarna. He became secretary to his uncle, Łukasz Watzenrode, Bishop of Warmia, and taking an active part in the political life of Royal Prussia he gained experience in diplomacy and administration, and also gradually became famous as a physician.

Let us start our tour of Lidzbark, one of the most important towns on the Copernicus Route, with the Gothic bishop's castle which after Malbork, is the most imposing example of defence building in northern Poland. At present, it houses a museum of Gothic and Baroque art of the Warmia and Mazury region and a special collection shows the cultural ties between Warmia and Cracow in past centuries.

In the large reception hall of the castle, under Gothic arches, the visitors can admire the coats-of-arms and inscriptions which name all the bishops of Warmia, among them Watzenrode, and Polish

Mazurian Lake District – a land of thousands of lakes, important recreation and water sports area.

defence of Lidzbark in 1520 against the army of Teutonic Knights lead by the Grand Master Hohenzollern. The High Gate, built in the 14th century, was once the entrance to the town, and is one of the largest structures of this type in Poland.
On a hill near the castle, Bishop Ignacy Krasicki laid out beautiful gardens in the Neo-classical style with avenues, ornamental paths, statues, and secluded places. Only a part of the park and the orangerie called "Krasiczyn" have survived from those times. The romantic tourist will appreciate an evening stroll along the avenues of the park as a final touch to his stay in Lidzbark Warmiński.


Konin
Koło
Kutno
E8
Bzura
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Sochaczew
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WARSZAWA
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E82
E7
Góra Kalwaria
Mszczonów
Grójec
E12
Warta
ŁÓDŹ
Zduńska Wola
Sieradz
TOMASZÓW MAZ.
Pilica
T12
PIOTRKÓW TRYB.
RADOM
Opoczno
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E16
E7
Wieluń
Radomsko
KIELCE
Jędrzejów
E7
Miechów
E22
E22a
Wisła
KRAKÓW
Bochnia
E22
Tarnów
ZAKOPANE
KALISZ
WROCŁAW
LUBLIN
LUBLIN
RZESZÓW
Main roads
Roads
Administrative frontiers of Warmia in the 16th-century
Places where Copernicus stayed
Interesting tourist towns on the Copernicus route
Museums with Copernicus souvenirs
Exhibitions open during the Copernicus Year
Roads leading to border crossings

Defence tower – part of fortifications of the Frombork cathedral – in which Copernicus resided and where he worked on his "De revolutionibus".

The Copernicus Museum in the former bishop's palace in Frombork has interesting collecions connected with the life and work of the great astronomer.

attempts to find the tomb of the great astronomer they have all failed so far.

When in the cathedral you may have the occasion to hear an organ concert played on the 17th-century instrument, one of the largest and finest in Poland. The sound of this organ is quite extraordinary, for the reverberation lasts nearly seven seconds. The famous concerts on the organ in Frombork are widely known in Poland and abroad.

Where did Copernicus live when in Frombork? Every canon usually hat two residences, one inside the defence walls, and the other outside. Inside the walls, the astronomer lived in the corner the north-western tower of the Frombork castle. Copernicus lived there for many years, and there he worked on his "De revolutionibus." The interior of Copernicus' Tower was reconstructed after the last war and a sundial placed on its top. Old documents show that apart from his residence inside the defence walls Copernicus had, at various times, stayed in several houses outside the walls.

In the bitter fighting of 1945 Frombork suffered heavy losses. On the cathedral hill part of the defence walls was ruined, as well as the old 16th-century palace of Bishop M. Ferber; at present, it houses the museum and is a real ornament of the hill. The reconstruction of Frombork was started already in 1945, and covered the famous Copernicus Tower, other bastions, as well as the octagonal bell tower, an imposing defence structure in the south-western corner of the hill. Reconstruction work was also started in the bishop's palace.

The town has acquired new housing, modern streets, and green spaces.

In our tour of the cathedral hill we must not forget the Copernicus Museum in the magnificent bishop's palace. The main aim of the museum is to present the life and work of Copernicus. In the large reception hall on the ground floor it would be worth while to listen to an introductory lecture on Frombork and its most prominent citizen. The first floor of the museum is devoted to Copernicus' stay in the Warmia region, and the second floor to the subject of Copernicus in modern art.

After visiting the town the tourist can relax on the beaches of the Bay of the Vistula or in its vicinity.

So we propose a trip by launch to the old town of Tolkmicko and further on to Krynica Morska, on the Vistula Peninsula, a known bathing resort and recreation spot.

Tourists should also visit Kadyny known for its stud farm.

Olsztyn – the capital of the Mazurian Lake District, an important tourist centre and a town in which Copernicus stayed.

OLSZTYN

The Copernicus Route now leads to Olsztyn, the capital of the Mazurian Lake District, the land of 1,000 lakes, romantic forests, nature preserves. The district has 100,000 inhabitants.
Two million tourists visit the region every year to spend their summer holidays on the shores of the lakes. Water sports, hunting, fishing, mushroom picking, beautiful views—these are the main attractions for people seeking rest and contact with nature. The beauty of this land is also well known beyond the boundaries of Poland; numerous foreign visitors come here every year in search of peace and silence trying to get away from the noisy city streets.
Copernicus visited Olsztyn twice: in the years 1516–1519 and 1520–1521 as the administraor of the chapter's estates and during that time resided in the castle of holding this distinguished, but at the same time very tiresome office, he spent much of his time travelling, settling peasants from Mazowsze on land that had been devastated during wars and invasions. While staying in the castle he would carry out constant night observations of the sky from his favourite tower to which special stairs lead from his room. During his stay in Olsztyn Copernicus also worked on improving

As administrator of the Warmia Chapter estates, Copernicus lived in this Gothic castle in Olsztyn in the years 1516–1519 and 1520–1521.

By now you have visited many cities directly connected with Copernicus, but, once on the Copernicus Route, is also worthwhile to see some other places, perhaps less important in the astronomer's life but still related to him in some way. Lubawa, Malbork, Elbląg, and Grudziądz, have many monuments of art and the memory of Copernicus is alive there.

Old documents tell that Copernicus arrived in Lubawa on April 27, 1539 to see the ailing Bishop Tiedemann Giese. A legends says that when during this visit Copernicus felt thirsty he was given a cup of water warm and tasteless. The bishop's guest took interest in this water and learned about a certain spring and a river flowing in a valley away from the town. Water from the river lost its freshness by the time it was brought to the castle. Copernicus calculated that it would not cause much trouble to carry the water to the castle by means of pipes. When in September of the same year Copernicus was leaving Lubawa, after a second visit in that town, Bishop Giese treated him to spring water brought by wooden pipes right to the courtyard of the castle. A water intake operating today in the same place has been named after Copernicus which proves his great popularity in those lands.

The above mentioned Copernicus' second visit to Lubawa came in July 1539; he then came to the town in the company of Jerzy Joachim Retyk, a young professor of mathematics from Wittenberg, at Bishop Giese's invitation. It was Retyk who persuaded Copernicus to publish his "De revolutionibus," which had been ready for a long time, and who spent many weeks studying it and getting ready for printing. The visit gave the two scientists a good rest after intensive work on the book.

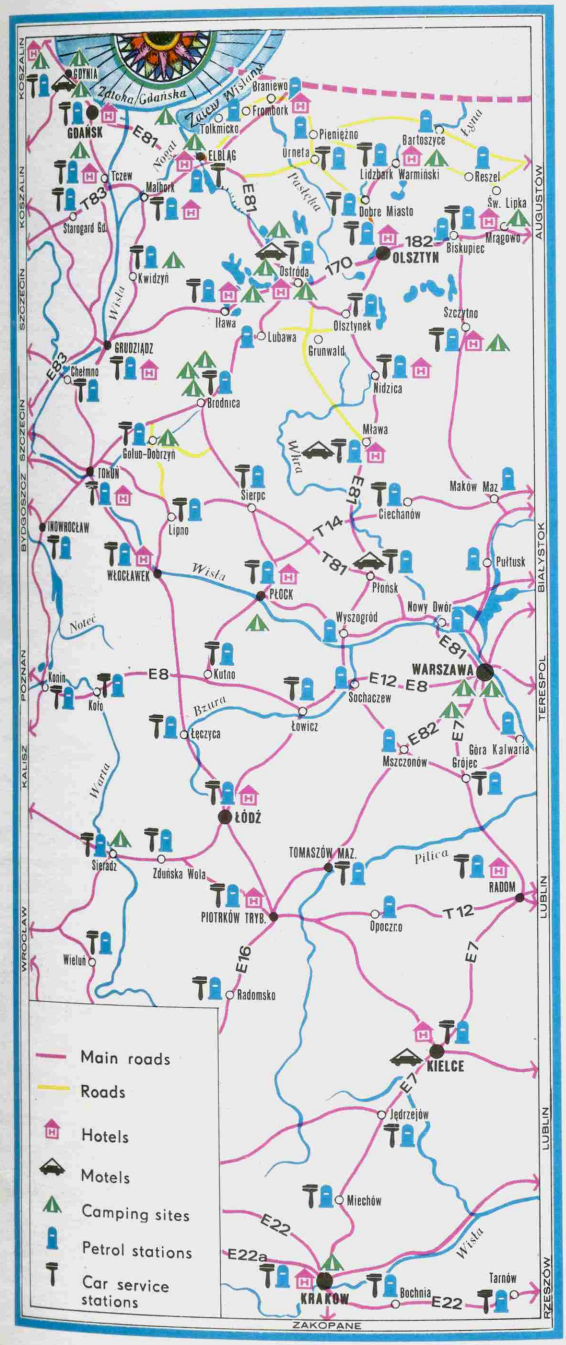
Malbork is another place Copernicus visited. The town is known for the grand Gothic castle which is one of the most interesting and best preserved examples of a fortress in that part of Europe. Copernicus came here on January 1st, 1504, with his uncle Łukasz Watzenrode, to attend the congress of representatives of Royal Prussia's estates convened by King Alexander the Jagellon. The Malbork castle houses a museum with a unique collection of amber.

The first documented visit of Copernicus in Elbląg is also connected with a congress of estates in 1504, which voted to ask the Polish king to come and administer an oath of loyalty to representatives of the country. Undoubtedly Copernicus travelled to Elbląg from Lidzbark via Braniewo, Frombork, Tolkmicko, and Kadyny, along an extraordinarily picturesque route running through a land of lakes and forests, along rivers meandering in green valleys and the Vistula Haff. This route was later marked on the first map of Poland (Tabula Sarmatiae), drawn by a friend of Copernicus, the brilliant cartographer Bernard Wapowski.

Elbląg is the largest industrial and cultural centre in the area as well as an important holiday resort. It was almost totally destroyed during the Second World War. Today, though, it is again flourishing and steadily growing. Elbląg is known throughout Poland for the production of huge turbines and modern metal sculptures that can be seen in the city streets, parks, and squares.

In 1522, Copernicus stayed in Grudziądz and it is there, at a session of the regional council, that he proposed a reform of the monetary system. The law about good money being driven out by bad money is known today as Gresham's law, named so after a British financier who lived in the 16th century and formulated it after Copernicus.

Copernicus' visits to these four towns is proven by documents. But on the Copernicus Route you shall find two small towns with magnificent monuments of art where the astronomer is also very likely to have stayed: Włocławek and Chełmno. Historians believe that after passing from a parish school in Toruń, Copernicus went to a cathedral school in either of these two towns.



INFORMATION

Branches of travel offices and a network of tourist information centres "it" in Toruń, Włocławek, Golub-Dobrzyń, Gdańsk, Malbork, Elbląg, Olsztyn, Frombork, Lidzbark Warmiński and Cracow provide information concerning:

- dining facilities
- accommodation in hotels, motels, and camping sites
- transport
- currency exchange
- cultural and tourist attractions on the Copernicus Route

Car owners can also receive detailed information concerning:

- petrol stations
- road service
- technical aid

In "it" centres tourists can receive foreign language publications, as guides and maps on routes and souvenirs connected with the life and activities of Copernicus.

CURRENCY EXCHANGE

Currency exchange centres can be found in the branches of the Polish National Bank, travel offices, larger hotels, border crossings, international airports, sea ports, international trains. The exchange of currency outside the official centres is prohibited and liable to prosecution.

POLISH TRAVEL OFFICE

"ORBIS"

Warsaw, ul. Bracka 16, tel. 26-02-71 – management

FOREIGN TOURISTS DEPARTMENT

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● organizes attractive holidays in Poland for individual tourists and groups, for amateurs of horseback riding, fishing, sailing and hunting ● exchanges foreign currency and buys vouchers ● facilitates car hire ● runs hotels, guest houses, restaurants.

INFORMATION:

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PTTK – Polish Tourist Association – Warsaw, ul. Świętokrzyska 36, tel. 20-82-41

SPORTS-TOURIST – Polish Tourist Association – Warsaw, ul. Moliera 8, tel. 27-39-46

ALMATUR – Travel and Tourist Offices of the Polish Students' Union – Warsaw, ul. Ordynacka 9, tel. 26-53-81

JUVENTUR – Foreign Youth Tourist Office – Warsaw, al. Róż 2, tel. 21-84-86

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"LOT"

Tickets and reservations:

Warsaw, ul. Waryńskiego 9, tel. 21-70-21
Warsaw, al. Jerozolimskie 44, tel. 27-13-66
Warsaw, ul. Grójecka 27, tel. 23-15-41

When travelling by air remember that the Polish Airlines LOT offer you quick and convenient connections on the

LONDON – WARSAW – LONDON

route, and have connections with European airports for all transatlantic flights.

Detailed information can be obtained through the agencies of the Polish Airlines "LOT" in:

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NEW YORK – 500 Fifth Avenue, N. Y. 10036, Suite 2125, tel. LO-4-8116
and in all the large European airports as well as in Beirut and Cairo

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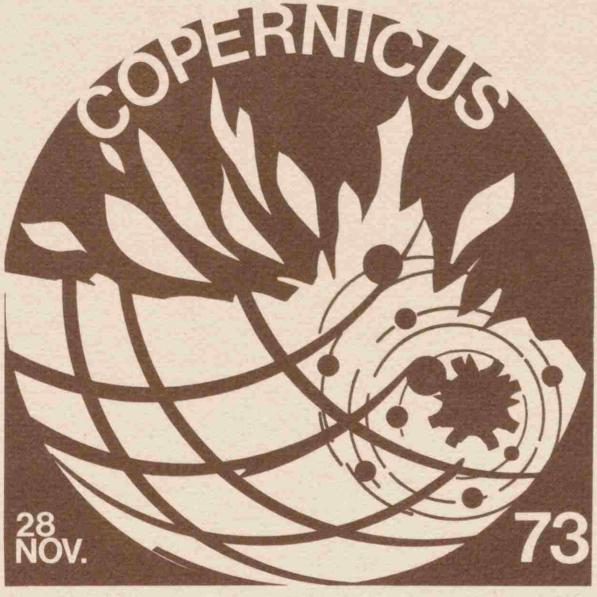
On the way to Poland you can use the PEKAES motorcoach connection from LONDON through OSTENDE, COLOGNE to POZNAŃ and WARSAW and in the summer from OSTENDE to WROCŁAW, KATOWICE and CRACOW.

Once a month there is a convenient connection with Poland by TS/S STEFAN BATORY of the Polish Ocean Lines, from MONTREAL through SOUTHAMPTON, ROTTERDAM, COPENHAGEN to GDYNIA.

From WARSAW you have air and railway connections with CRACOW, SZCZECIN, GDAŃSK, KATOWICE, WROCŁAW and other Polish cities.



1473 - CELEBRATION DE COPERNIC - 1973

La Société royale du Canada

NICOLAUS COPERNICUS

JALONS BIOGRAPHIQUES		BIOGRAPHICAL HIGHLIGHTS
Né à Toruń.	**19 February 1473**	Born in Toruń.
Etudiant à l'Université de Cracovie.	**1491 - 1495**	Studied at the University of Cracow.
Etudiant en droit à l'Université de Bologne.	**1496 - 1501**	Studied law at Bologna University.
Etudiant en médecine à Padoue.	**1501 - 1503**	Studied medicine in Padua.
Doctorat en droit, Université de Ferrare.	**1503**	Received doctor degree in law, University of Ferrara.
Préparation de l'exposé sur la théorie héliocentrique: "Nicolai Copernici de Hypothesibus Motuum Coelestium a se Constitutis Commentariolus".	**1507**	Preparation of the text outlining heliocentric theory: "Nicolai Copernici de Hypothesibus Motuum Coelestium a se Constitutis Commentariolus".
Publication à Cracovie de la traduction de Copernic du grec au latin de "Lettres" de Theophylaktos Simokattes.	**1509**	Publication in Cracow of Copernicus Latin translation of Greek "Letters" by Theophylaktos Simokattes.
Traités d'économie "Sur la valeur de l'argent" et "Sur la méthode de frapper la monnaie" (Monete Cudende Ratio).	**1517 - 1519 - 1528**	Treatises "On the Value of Money" — "On the Method of Minting Money" (Monete Cudende Ratio).
Gouverneur et défenseur de la ville d'Olsztyn, attaquée par les Chevaliers teutoniques.	**1521**	Governor and defender of the city of Olsztyn attacked by Teutonic Knights.
Administrateur général des domaines capitulaires de Varmie.	**1523**	Administrator General of Capitular estates in Warmia.
Termine le manuscrit de son oeuvre monumentale: "De Revolutionibus Orbium Coelestium Libri VI" (Sur les révolutions des sphères célestes, en six volumes).	**1530 - 1532**	Completed the manuscript of his monumental work: "De Revolutionibus Orbium Coelestium Libri VI" (On the Revolutions of the Heavenly Spheres, Six Books).
Meurt à Frombork; publication de "De Revolutionibus".	**24 May 1543**	Died in Frombork Publication of "De Revolutionibus".

1473 — COPERNICUS CELEBRATION — 1973

Ottawa, Canada

28 November 1973

ROYAL SOCIETY OF CANADA LECTURES —

ON A DISQUIETING EARTH
500 YEARS AFTER COPERNICUS
The Auditorium of the National Library, 395 Wellington Street

After a brief introductory talk on Nicolas Copernicus and his work, prominent Fellows of the Royal Society of Canada will discuss contemporary problems in a broad social context.

9:30 — **Opening remarks**
DR. GUY SYLVESTRE
President, The Royal Society of Canada, Ottawa.

9:40 — **Nicolas Copernicus — Scientist, Humanist, Man**
Some Reflections 500 Years After His Birth
DR. T. J. BLACHUT
Head, Photogrammetric Research, National Research Council, Ottawa.

10:00 — **Science as a Way of Life**
DR. C. E. DOLMAN
Professor Emeritus, Department of Microbiology,
University of British Columbia, Vancouver.

11:00 — Coffee

11:30 — **The Times of Signs: an Essay on Science and Mythology**
DR. H. N. FRYE
Professor, English Department, University of Toronto, Toronto.

15:00 — **Images du monde et images de l'homme.**
Vers un décentration totale?
DR. JEAN-PAUL AUDET
Professor, Department of Philosophy, University of Montreal, Montreal.

16:00 — Coffee

16:30 — **Perspectives for Progress**
DR. J. M. HARRISON
Assistant Director-General for Science, UNESCO, Paris.

EXHIBITION — **"KOPERNIK"**
The National Library, 395 Wellington Street

18:00 — The exhibition, prepared especially for the occasion by the National Library, will be officially opened by the Honourable MITCHELL SHARP, Secretary of State for External Affairs.

18:30 — A reception will be given by DR. GUY SYLVESTRE, National Librarian.

COMMEMORATIVE EVENING — **CONCERT**
The Opera of the National Arts Centre

20:30 — The NAC Orchestra, conducted by MARIO BERNARDI, will present:

a) **Elegy for Orchestra** by TADEUSZ BAIRD,
World Première of a work by this leading Polish composer, commissioned by the National Arts Centre for the celebration of the 500th anniversary of the birth of Copernicus.

b) **Concerto No. 2 in B Flat** by Brahms.

c) **The 6th Symphony in C** by Schubert.

REGISTRATION

The registration fee of $10.00 per person or $15.00 per couple covers the entire programme: the Lectures, the opening of the Exhibition and the reception afterwards, together with one ticket per person for the Concert. All registrants will also receive one copy of the book containing the texts of the lectures presented. The registration fee of $3.00 for students does not include the book.

In order to participate, please send the completed registration form as soon as possible to the Royal Society of Canada at the address shown on the form. Seating space is limited.

1473 — CELEBRATION DE COPERNIC — 1973

Ottawa, Canada

le 28 novembre 1973

CONFERENCES DE LA SOCIETE ROYALE DU CANADA —

SUR UNE TERRE INCERTAINE
500 ANS APRES COPERNIC
Auditorium de la Bibliothèque nationale, 395, rue Wellington

Après une brève introduction sur la vie et l'oeuvre de Nicolas Copernic, des membres éminents de la Société royale du Canada se pencheront sur quelques problèmes de la société contemporaine.

9 h 30 — **Discours inaugural**
par M. GUY SYLVESTRE,
président de la Société royale du Canada, Ottawa.

9 h 40 — **Nicolas Copernic: savant, humaniste, homme,**
quelques réflexions 500 ans après sa naissance
par M. T. J. BLACHUT,
directeur, section de photogrammétrie, Conseil national de recherches, Ottawa.

10 h 00 — **Science as a Way of Life**
par M. C. E. DOLMAN,
professeur émérite, Département de microbiologie, Université de Colombie-britannique, Vancouver.

11 h 00 — Pause café

11 h 30 — **The Times of Signs: an Essay on Science and Mythology**
par M. H. N. FRYE,
professeur, Département d'anglais, Université de Toronto, Toronto.

15 h 00 — **Images du monde et images de l'homme.**
Vers une décentration totale?
par M. JEAN-PAUL AUDET,
professeur, Département de philosophie, Université de Montréal, Montréal.

16 h 00 — Pause café

16 h 30 — **Perspectives for Progress**
par M. J. M. HARRISON,
directeur général adjoint de la section Science, UNESCO, Paris.

EXPOSITION — **"KOPERNIK"**
Bibliothèque nationale, 395, rue Wellington

18 h 00 — Inauguration de l'exposition "Kopernik" par l'honorable MITCHELL SHARP, secrétaire d'Etat aux Affaires extérieures. Cette exposition a été préparée spécialement pour la circonstance par la Bibliothèque nationale du Canada.

18 h 30 — Réception offerte par M. GUY SYLVESTRE, directeur général de la Bibliothèque nationale du Canada.

SOIREE COMMEMORATIVE — **CONCERT**
Opéra, Centre national des Arts

20 h 30 — L'orchestre du CNA, dirigé par MARIO BERNARDI, exécute:

a) **Elégie pour orchestre** de TADEUSZ BAIRD
Première mondiale de cette oeuvre de l'éminent compositeur polonais, commandée par le Centre national des Arts pour commémorer le 500e anniversaire de naissance de Copernic.

b) **Concerto nº 2, en si bémol majeur** de Brahms.

c) **Symphonie nº 6, en do majeur** de Schubert.

INSCRIPTION

Les frais d'inscription sont de $10.00 par personne ($15.00 par couple) et couvrent le programme entier de la journée: colloque, exposition, réception, un billet par personne pour le concert ainsi qu'un exemplaire du livre comprenant les textes des conférences. L'inscription réduite à $3.00 pour les étudiants n'inclut pas le livre.

Si vous désirez participer à la "Journée Copernic", veuillez remplir la formule d'inscription ci-jointe et la faire parvenir immédiatement à l'adresse indiquée. Le nombre de places est limité.

The Kingston Whig-Standard

Continuing since 1926 The British Whig founded 1834 and The Kingston Daily Standard, founded as The Kingston Gazette 1810.

FORTY-SEVENTH YEAR

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MONDAY, FEBRUARY 19, 1973

Copernicus

Five Hundred Years Of Astronomical Advancement

A. Vibert Douglas
Emeritus Professor of Astronomy, Queen's University

Two hundred years before Kingston was founded a boy was born in Torun in western Poland, a boy destined to grow up to become Copernicus, the man who changed the entire cosmological outlook of mankind.

This year, 1973, is therefore the five hundredth anniversary of his birth and commemorative ceremonies and addresses will take place in scores of cities around the world. In Poland, in late summer, a large group of astonomers and historians of science from many lands will gather in Warsaw to hold a special Assembly of the International Astronomical Union, listening to, and discussing papers given by invited scholars. The delegates will then visit Torun, that picturesque Hanseatic town on the broad navigable Vistula, where the Copernicus University has been established along with an observatory for astronomical research, both optical and radio. Here they will see the house where he was born and nearby, on the wall above the baptismal font in the parish church, a plaque commemorating his christening.

Nickolai Koppernigk, who later took the Latinized form of his name, Copernicus (as was the habit of scholars in his day) was educated in the ancient university of Crackow in southern Poland, and afterwwards in three famous universities of Italy, Bologna, Ferrara and Padus, studying mathematics, astronomy, medicine and ecclesiastical law.

His uncle, the Bishop of Varnia, appointed this scholarly nephew a Canon of Fraunenburg Cathedral and here Copernicus resided for the rest of his life. His duties as physician to the clerical community, and occasionally to ranking personages outside Varnia, gave him time for astronomical studies and observation of the relative positions of the planets. At the same time, his uncle placed more and more administrative work upon him. When the Teutonic Knights attacked Varnia unsuccessfully, Copernicus was the official who negotiated the peace and reparations settlement. When the currency became debased, Copernicus enunciated the forerunner of Gresham's Law, and oversaw the minting and valuation of the new money.

But the fame of Copernicus rests not on these achievements but on his great book *Concerning the Revolutions of the Heavenly Bodies* published just prior to his death in 1543. Since the years at Bologna where he first read the Greek cosmologies, he was impelled to obtain confirmation of the speculations of Aristarchus of Samos that the earth was not the centre of the universe with sun, moon, planets and stars revolving around it, but rather the sun was the central body and the earth a planet. Gradually over the years, Copernicus accumulated the observations which proved convincing that "in the midst of all stands the sun." In orbits around it revolved Mercury, and further out, Venus, then next was the earth with the moon as its satellite; beyond them were Mars, Jupiter and Saturn. The more remote planets were only discovered after the invention of telescopes.

Religious intolerance of new ideas and the persecutions which the Roman clerics inflicted upon 'heretics' made Copernicus delay publication, only discussing his theory and evidence with scholars who risked their own reputations in the interests of the search for truth. One of these men urged publication and arranged for it. One Cardinal with the courage to face the facts of the physical world, gave his approbation and so the great book was published ~~five hundred~~ 430 years ago.

A few years later, the Pope placed it on the Index where it remained far into the 19th Century. But as King Darius of Persia had affirmed centuries before Copernicus, "Great is Truth and it will overcome all things." And so the ancient conception of the earth-centred universe gave way, very gradually, but inexorably, to the heliocentric universe of Copernicus.

The growth of knowledge is truly an exciting story. In the last century, astronomers have found that the solar system is not at the centre of the universe; it lies far out from the hub of our vast Milky Way System of many thousand million stars (our galaxy), and in this century it has been established that our galaxy is only one of many, many millions of other galaxies, the more distant ones unseen even by the great optical telescopes but recorded by the radio telescopes. With this vast enlargement of our physical universe as men's thoughts have moved outward from the confines of the pre-Copernican cosmology, philosophers and theologians have been compelled to modify and expand their thinking.

This profound revolution began with Copernicus and that is why the thinking world is commemorating the five hundredth anniversary of his birth (February 19, 1473).

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COPERNICUS 1473–1543*

By A. Vibert Douglas
Kingston Centre, R.A.S.C.

The life span of Copernicus covers a period in history filled with movement in many spheres of human endeavour. It was an age of intolerance and reaction on the one hand and of high adventure and daring on the other.

These were the years when Michelangelo was at work in the realm of art; when Martin Luther was breaking with traditional theology and fighting for freedom of thought and conscience in the realm of religion; when Paracelsus was vitalizing mediæval medicine and Vesalius was making of anatomy a modern science; when the Moors with their rich Arabic learning were being pushed out of Spain, while Italy, the main centre of European scholarship, was gradually awakening from an intermittent sleep of twelve centuries. In these years when Christopher Columbus was sailing uncharted seas to discover the islands of a new continent, Copernicus was turning his back upon the ancient cosmologies to give the world the heliocentric model of the Universe.

In the thirteenth century the Teutonic Knights had founded the town of Torun or Thorn on the broad, navigable Vistula. This became an important trading port of the Hanseatic League. From Cracow, the chief town of Poland, a prosperous merchant named Niklas Koppernigk moved to Torun, married the daughter of a Polish-German merchant of that town, and on Feb. 19, 1473 their fourth child, Niklas, was born. This boy grew up to become one of the makers of modern thought. When he reached the stage of productive scholarship, he followed the custom of the scholars of his day by publishing his works in Latin, and like so many of them he Latinized his name as author. Thus we know him not as Niklas Koppernigk, but as Copernicus.

*This article is based on a paper which appeared in the Queen's Quarterly, vol. L, no. 2, 1943 commemorating the 400th anniversary of his death.

The education of Copernicus was long and varied. From the school of Torun he went to the University of Cracow in 1491. Here he found a strong school of mathematics and astronomy and no doubt studied the only two cosmologies that had survived the centuries since the rich speculative and mathematical period of Greek science. The simple Aristotelian system was based upon the geocentric universe of Pythagoras. The more complicated Ptolemaic system was built upon the ingenious work of the great Greek geometers who used circles and epicycles to reproduce the apparent motions of sun, moon and planets. While the Earth was not placed at the centre of these circles, it was still within the circles of all the heavenly bodies, and thus sun, moon, planets and stars moved around it.

In 1496 Copernicus went to Bologna where he worked at the school of law for four years. Here too he found astronomical interests in the observations and theories of the professor of astronomy, a brilliant man with an independent, critical mind, a leader in the current revival of Platonism. To the left of the great bronze doors to the Assembly Hall is a plaque to Dante Alegheri, Scholar in Bologna, 1287, and on the right a plaque to "Copernicus of Poland glorious son of this institution", erected in 1836.

Copernicus next went to Rome where he took private pupils in Mathematics, but a year later he resumed his legal studies at Padua. Here he also studied Greek and began his wide reading in Greek science which led to his discovering for himself the half-forgotten speculations of Heraclides, Ecphantus and Hicetas on the axial rotation of the earth, and the heliocentric system of Aristarchus of Samos. This last was indeed a forerunner of the great scientific life-work of Copernicus, but it had been backed up in the third century B.C. by not one logical argument based upon astronomical observation which could overthrow the amazing partial success of the elaborate systems built upon the epicycles of Eudoxus.

Leaving Padua, Copernicus went to Ferrara where in 1503 he obtained his doctorate in Canon Law. He then returned to Padua and applied himself to the study of medicine until the end of the year 1505. In the meantime his uncle, the Bishop of Varmia or Ermland, had succeeded in getting this scholarly nephew elected to a canonry at Frauenburg Cathedral. This appointment imposed no obligation to advance in ecclesiastical position beyond the first vows necessary for admission, and beyond this first stage Copernicus never went although he remained a member of the Chapter until his death thirty-seven years later.

For six years after taking up his residence as a Canon of Frauenburg, Copernicus served as medical attendant upon his uncle at the Bishop's palace which was the castle of Heilsburg. Here he was able to devote time to astronomical pursuits as well as to exercise the art of healing amongst the

ecclesiastics and the poor of the diocese, on one occasion being summoned to Königsberg by the Duke of Prussia to attend a high official in his grave illness. At this time, too, he became experienced in political and administrative work. Varmia was trying to maintain a measure of independence with the powerful Teutonic Knights on three sides and Poland on the fourth. The Bishop had many problems arising from a population partly German, partly Polish, within his own principality; and also in neighbouring West Prussia where he was asked to mediate in the racial dispute. Copernicus carried out diplomatic missions for his uncle and after the Bishop's death he was entrusted with the temporal and spiritual administration of the remoter parts of the diocese. Later when war developed between Poland and East Prussia involving the would-be neutral territory of Varmia with bombardment, raids and pillage, Copernicus proved himself the strong man with high qualities of leadership and practical foresight. At the peace conference following the 1521 armistice it was Copernicus who presented the claims of Varmia for war damage.

The coinage of the Prussian states, already debased before the war, now presented very serious problems, both internally and in neighbouring states. Copernicus placed before the local diet a scheme for monetary reform, and in a report published first in German and later in Latin he set forth his plan for recoinage and enunciated what later became known as Gresham's Law.

During these years with their multifarious duties, Copernicus had laid the foundations of his planetary theory and written the first draft of *De Revolutionibus Orbium Coelestium*. He had used the primitive instruments then in vogue to make observations upon some of which the arguments in favour of his theory were based. He had published accounts of the construction of a meridian quadrant and of a Ptolemaic astrolabe. One work only of a purely literary character came from his pen, his Latin translation of the Greek Epistles of the poet Simocatta, published in Cracow in 1509 when he was in that city on diplomatic business.

For six months in 1523 Copernicus was the Administrator-General of the diocese. Then a new Bishop was appointed and thereafter Copernicus was less burdened with the affairs of the world about him and could give closer attention to the astronomical problems which had absorbed his thoughts for so many years. Peace had come to the land with the triumph of Poland over the Teutonic Knights; but there could be no peace in the minds of thinking men and seekers after truth. Intolerance was growing and was soon to reach new peaks of viciousness in defence of orthodoxy against the teachings of Luther and against any scholarly work that cast a shadow of doubt upon that amazing synthesis, by St. Thomas Aquinas and other Church Fathers, of Judaic thought, Christian doctrine and Greek philosophy and science.

In the years 1523-32 Copernicus revised the manuscript of his great book, but apparently he made no attempt to publish it. It was known to exist, however, but only a very few scholars had the vision and the courage to be openly interested. In 1536 Cardinal Schönberg of Capua wrote to Copernicus as follows:

> Having constantly heard of your talent, I have begun to honour you more fully, and to congratulate our countrymen amongst whom you have flourished with so great renown. For I had perceived that you were not only well versed in the works of the old mathematicians, but also had propounded a new theory of the universe. By it you teach that the earth moves, that the sun is at the bottom of the universe, and indeed holds the middle place. That the eighth heaven remains immovable and eternally fixed. That the moon, with the elements included in her sphere, placed between the heaven of Mars and Venus, revolves in a yearly course round the sun. And that you have written commentaries on this whole theory of astronomy, and have reduced into tables the motions of the planets, computed from calculations, to the great admiration of everyone. Wherefore I beseech you, most learned man, if I am not troubling you, to impart this your discovery to the learned, and also to send to me in the first place your lucubrations concerning the sphere of the universe, with the tables, and anything else you have pertaining to the same matter. And if you will gratify me in this, you will find that you have to do with a man careful of your name, and one anxious to do justice to such great talent. Farewell. At Rome, Calends of November, 1536.

In 1539 a youthful German professor of mathematics came to visit Copernicus at Frauenburg. His name was Joachim von Lauchen, alias Rheticus, and as he was one of Melanchthon's men from the Protestant University at Wittenberg, not only was he running a risk himself remaining in an atmosphere of latent hostility and suspicion, but his presence inevitably focused suspicion on Copernicus. Nevertheless the Canon of Frauenburg welcomed Rheticus, expounded his cosmology, encouraged him to summarize the manuscript and to publish the summary in Danzig in 1540. On his next visit Rheticus summarized the chapters dealing with plane and spherical trigonometry which Copernicus had brought together and generalized from the works of Ptolemy, and these he published at Wittenberg in 1542.

Copernicus had obviously withheld his book lest its publication should lead to open opposition to his investigations, but he now wrote to Osiander, a Lutheran theologian and an able mathematician, asking him whether in his judgement the work would give offence. Osiander's reply dated April 20, 1541, is in part thus "... I have always felt about hypotheses that they are not articles of faith, but bases of calculations ..."

Copernicus, now nearing seventy years of age, at length determined to publish his completed work. He inscribed his Preface, "To the Most Holy

Lord Pope Paul III", Osiander wrote an anonymous foreword, and Rheticus arranged that the book should be printed at Nürnberg. Soon after this Copernicus was stricken with paralysis from which he never recovered though he lingered on for a few months. On May 24, 1543, the first copy of *De Revolutionibus* was received from the publishers. It was placed in his hands. He saw it and was glad. A few hours later Copernicus was dead.

Four hundred and thirty years ago the words of Osiander supplied a temporary and partial camouflage for the dynamite which the book contained. Copernicus had written,

> First and above all lies the sphere of the fixed stars, containing itself and all things, for that very reason immovable; in truth the frame of the universe, to which the motion and position of all other stars are referred. Though some men think it to move in some way, we assign another reason why it appears to do so in our theory of the movement of the earth. Of the moving bodies first comes Saturn, who completes his circuit in xxx years. After him, Jupiter, moving in a twelve year revolution. Then Mars, who revolves biennally. Fourth in order an annual cycle takes place, in which we have said is contained the earth, with the lunar orbit as an epicycle. In the fifth place Venus is carried round in nine months. Then Mercury holds the sixth place, circulating in the space of eighty days. In the midst of all dwells the Sun. Who indeed in this most beautiful temple would place the torch in any other or better place than one whence it can illuminate the whole at the same time? Not ineptly, some call it the lamp of the universe, others its mind, others again its ruler – Trismegistus, the visible God, Sophocles' Electra, the contemplation of all things. And thus rightly in as much as the Sun, sitting on a royal throne governs the circumambient family of stars ... We find, therefore, under this orderly arrangement, a wonderful symmetry in the universe, and a definite relation of harmony in the motion and magnitude of the orbs, of a kind which it is not possible to obtain in any other way. (*De Revolutionibus*, Bk. I, Chap. X.)

"In the midst of all dwells the Sun." He postulated three motions of the Earth, (i) a diurnal rotation from west to east about the polar axis; (ii) an annual revolution about the Sun in the plane of the ecliptic; (iii) a variation in inclination of the Earth's axis to the line joining Sun and Earth. Thus he explained the apparent daily rotation of the heavens, the apparent annual motion of the Sun through the constellations of the Zodiac, and the cycle of the seasons. He discussed the motion of the moon as a satellite of the Earth. He dealt with the motions and relative positions of the two inner and three outer planets, explaining their sidereal and synodic periods. He affirmed the extreme distance of all the stars, so great that the Earth's orbital motion produced no apparent parallactic shift of the stars. All this was elaborated with diagrams and position tables, and a weight of evidence so great as to leave no careful reader of *De Revolutionibus* with any vestige of doubt but that Copernicus intended his heliocentric planetary theory to be regarded as a statement of physical fact.

Small wonder, then, that when the far-reaching significance of this book was realized, timid, bigoted and intolerant ecclesiastics denied its implications and discouraged the study and discussion of its arguments by threat of torture and the stake. It was not, however, placed upon the Index until 1616, but there it remained until 1835.

William Gilbert in England and Giordano Bruno in Italy, both born in the 1540's, became the first notable men outside central Europe to convince themselves that a new light had dawned in astronomical thinking, and a new universe lay open to the eyes and minds of men. Gilbert advocated the Copernican theory and lived to publish his famous *De Magnete* and to die in 1603 respected and honoured in Elizabethan England. But Bruno's advocacy of the same theory placed his life in jeopardy. He escaped from Italy and proceeded to expound the Copernican cosmology and his own somewhat pantheistic but rather beautiful philosophy in Geneva but fled the intolerant disapproval of Calvinism. In Paris and later in Oxford and in Wittenberg he discoursed upon the new theory, being generally opposed but arousing interest in it wherever he went. Lured back to Italy on a promise of freedom to think and teach what he believed true, this scholarly disciple of Copernicus in science and of von Cues and Ramón Lull in philosophy went to the stake in Rome in 1600 for his advocacy of new ideas.

Sixty-seven years after the death of Copernicus Galileo placed the Copernican Theory on so firm a footing of new astronomical observations that his name stands linked with those of Copernicus before him and Sir Isaac Newton following him at this great turning point in the history of human thought.

Thus Copernicus and his book ushered in the renaissance of learning in astronomical science. During the centuries which have followed, knowledge has grown from more to more. Copernicus had displaced the Earth from the centre of the Universe and man's abode had become a minor planet. In a later century the Sun and planets were removed from a central position in the stellar universe to an inconspicuous place more than half way out along a radius of the Milky Way system. In our own century our galactic system has become only one of many million stellar galaxies. Circles gave place to Kepler's elliptic orbits three centuries ago. Nothing now remains static, neither earth nor sun nor stellar galaxy, not even the framework of space itself in the Lemaîtrian speculations of an expanding universe.

The repercussions of the Copernican cosmology upon philosophy were inevitably far reaching, though Copernicus himself seems not to have realized the full implications of his work in this respect. His great successor, Galileo, boldly drew the inferences – if a geocentric cosmology had to be abandoned, anthropocentric philosophy must likewise go. Henceforth the man of science must investigate nature with complete objectivity. Philosophy

must break away from the shackles of teleology focused upon man. Man was no longer obviously of prime importance as had been so easy to assert in the ancient world with its geocentric outlook. For man the sun and moon rose and set, for him the stars shone forth, for him the rains fell and the earth produced her increase – "Thou madest him to have dominion over the works of Thy hands, Thou hast put all things under his feet". If today man be regarded as of great intrinsic worth, it is not because this is an inevitable deduction from a survey of the physical universe, it must be for intellectual and spiritual reasons. Such reasons, happily, are not wanting when we study the character, achievements and influence of such men as Copernicus, men filled with courage and with "the divine afflatus of the truth-seeker".

The Director and staff
of
The National Museum of Science
and Technology
request the honour of your presence
at the official opening of
A SPECIAL EXHIBIT
to mark the 500th anniversary of
the birth of the Polish astronomer
NICOLAUS COPERNICUS
8:30 P.M.
Thursday, July 19, 1973
1867 St. Laurent Blvd., Ottawa
Reception following opening ceremonies
R.S.V.P.
996-6065

Le Directeur et les employés
du
Musée National des Sciences
et de la Technologie
ont l'honneur de vous inviter
à l'ouverture d'une
EXPOSITION
marquant le cinq centième anniversaire
de la naissance de l'astronome polonais
NICOLAUS COPERNICUS
à 20h 30
le jeudi 19 juillet 1973
1867 boulevard Saint-Laurent, Ottawa
L'ouverture sera suivie d'une réception
R.S.V.P.
996-6065

Copernicus at Frombork
Poland

Copernicus and his Long Revolution

Endeavour May 1973

J. R. Ravetz

All over the world this year is being celebrated the memory of a man born 500 years ago in Poland. During his lifetime he was a busy civil servant, who could take only occasional time off to pursue his private hobby, astronomy. Although he had sympathetic friends and a few distant colleagues who respected his work, his life's endeavour was a solitary one. Centuries later, we honour him for his achievement in astronomy and cosmology, and for his moral courage in persevering with his life's work in the face of the greatest difficulties and discouragements.

Copernicus was truly a great scientist, in the way he combined complete technical mastery with superb theoretical daring. In his time, and for decades after, the idea of the Earth's moving was patently ridiculous, contrary to commonsense, to accepted physics, and to sacred Scripture. By his commitment to this idea, Copernicus was inspired to produce a masterpiece of astronomy in which it was embedded. Out of this flowed the many consequences, including a century of debate that we now call 'the Copernican Revolution'. In the course of this were established the presuppositions and style of our modern physical science; hence our indirect indebtedness to Copernicus is very great indeed.

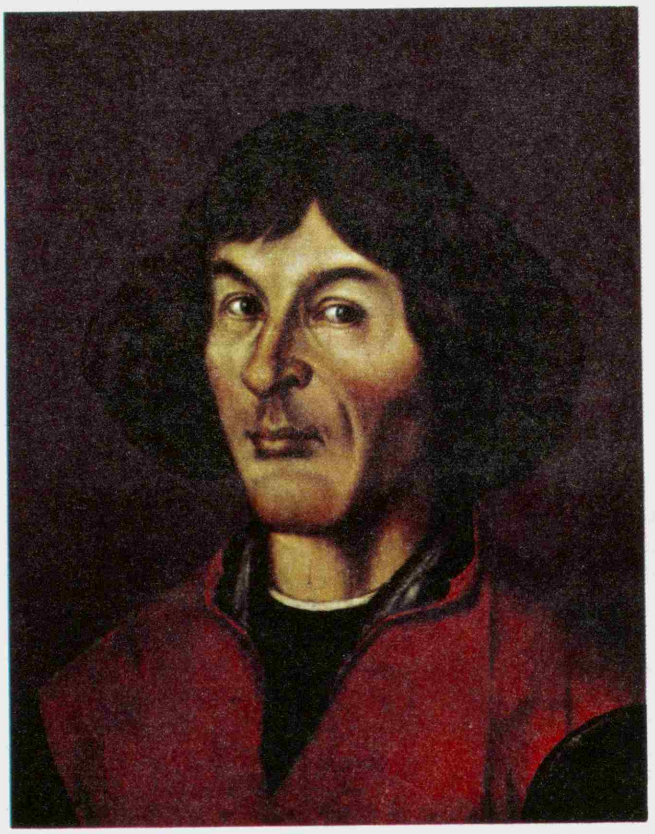


Figure 1 Nicolaus Copernicus, after an original portrait from Strasbourg, known as the 'Toruń Portrait'.

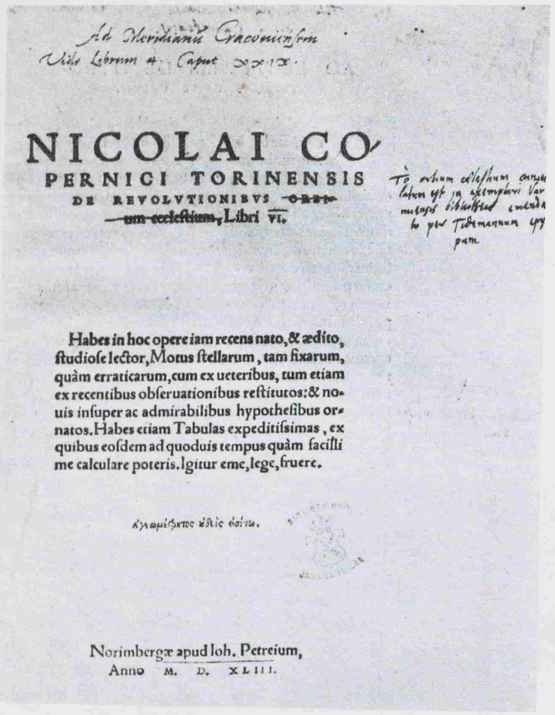
Nicolaus Copernicus was born on 19th February 1473 (old style) to a Polish burgher family of Toruń in Northern Poland [1]. The family name has sometimes been thought to derive from the German *Kupfer*, for copper; but it seems much more likely that the place-name in Upper Silesia 'Copernik' (the presumed origin of the surname) is a Polish description of a locality 'plentiful in dill' (the kitchen herb). The question of the 'nationality' of Copernicus may now seem anachronistic for historical study, and also irrelevant to any serious assessment of his significance, but there is a long tradition—happily now buried by both Polish and German scholars—of argument over his 'nation'. In this way arts scholars were in former times enlisted or used in support of power politics; and the Copernican historiography was much influenced in the past by these wider connections.

Although Copernicus's father died when he was only ten years old, he was supported by a maternal uncle, Lucas Watzenrode, who seems to have groomed him for succession to his own position of ecclesiastical eminence. With his elder brother Andrew (who died in 1518) he entered the University at Cracow in 1491. The University had for some decades been benefiting from the general renaissance of Polish life under the Jagiellonian kings. Within the charming modern city of Cracow (still reminiscent of the Emperor Franz Joseph) there are churches and castles (such as the Wawel) that recall a glorious Royal past. Although then one of the more remote outposts of European high culture, Cracow was closely connected with Italian humanistic circles, and the University, much of which survives, supported a substantial and lively group of teachers of mathematics and astronomy.

We know from manuscript sources that Copernicus did some astronomical calculations while a student at Cracow, going far beyond the elementary qualitative doctrines that were the standard fare for students, themselves likely to be mainly intending doctors picking up a smattering of 'mathematical physic' or astrological medicine. Whether he actually conceived his revolutionary theory while a student there, we do not know. The short essay containing the first draft of his world-system, the *Commentariolus*, has not yet been firmly dated on internal evidence. I believe it likely that it was composed before Copernicus left Cracow for Italy in 1492, but this is as yet a minority view. We are even less sure of the path along which he was first led to his conviction of the axial rotation and orbital revolution of the Earth. The 'problem of the planets' has seemed an obvious choice, but the text is nowhere explicit and other problems may well have been important.

J. R. Ravetz, *Ph.D.*

Was born in 1929 in Philadelphia and attended Swarthmore College. He came to England on a Fulbright Scholarship in 1950 and obtained his Ph.D. in pure mathematics at the University of Cambridge. After teaching at the University of Durham he moved in 1957 to Leeds, where he is now Senior Lecturer in the history and philosophy of science. His book on Copernicus, 'Astronomy and Cosmology in the Achievement of Nicolaus Copernicus' was published in Warsaw in 1965. His most recent work has been on the social and ethical problems of contemporary science.



NICOLAI CO
PERNICI TORINENSIS
DE REVOLVTIONIBVS
um ecclesium, Libri VI.

Habes in hoc opere iam recens nato, & ædito, studiose lector, Motus stellarum, tam fixarum, quàm erraticarum, cum ex ueteribus, tum etiam ex recentibus obseruationibus restitutos: & nouis insuper ac admirabilibus hypothesibus ornatos. Habes etiam Tabulas expeditissimas, ex quibus eosdem ad quoduis tempus quàm facilli me calculare poteris. Igitur eme, lege, fruere.

Norimbergæ apud Ioh. Petreium,
Anno M. D. XLIII.

Figure 2 Title page of the first edition of 'De revolutionibus . . .' printed in Nuremberg, 1543. (Figures 1 and 2 are reproduced by kind permission of Centralna Agencja Fotograficzna, Warsaw.)

In all outward respects, Copernicus's career was of a standard sort for a 'civil servant' of his time. He was provided with a canonry at Frombork Cathedral in the diocese of Varmia in North-Eastern Poland, where his uncle was then Bishop. Then at the age of 19 he set off to study canon law at Bologna, staying three years and enduring traditional financial difficulties. A visit home in 1501 secured a further two years on a modest stipend for the study of medicine. This he pursued at Padua, but he took his doctorate (in canon law) at Ferrara, probably because it was cheaper there. Returning to Poland in 1503, he spent the remaining forty years of his life in Varmia, as an administrator, diplomat, and physician. The only noticeable incident in which his career was extraordinary was his leaving the personal service of his uncle in 1510, about two years before his uncle's death. Copernicus thereby removed himself from the path of advancement, for the sake of a humbler life as one of a group of canons administering the Cathedral and its province, and with the hope of more leisure for his astronomy.

From Copernicus's public career we have a scattering of administrative and diplomatic documents. The calls on his time and talents were many and varied; he was frequently called on for medical treatment and advice. Varmia lay in a troubled land, with the Teutonic Knights a constant threat, and there were also some reverberations of Luther's reformation uncomfortably close at hand. His one signed publication during his life was a Latin translation of a collection of Greek letters. This had probably been his means of instructing himself in Greek while in Italy, and in 1509 a humanist friend published them. Of more importance was an *Essay on the Coinage of Money* (1517), written in response to urgent practical problems, in which he stated the principle now known as 'Gresham's Law'. Three languages were used in the milieu of Copernicus. Polish was the vernacular of Poles of all classes, and Latin served for their official business. German was used for commerce and official affairs by the urban merchants and by the Teutonic Knights. Copernicus's official documents were in Latin, or German, or both, depending on their function.

Near the end of his life Copernicus remarked that he had worked on his astronomical system 'into the fourth period of nine years'. By modern standards, one book (and no published research papers!) in thirty years is a very low productivity. Of course, his hours of uninterrupted leisure for this work must have been few; and in spite of contacts with friends and informants in and outside Poland, almost all the work, including some fundamental observation, was done single-handed. By the time the work was approaching completion, Copernicus became reluctant to see it published, in spite of the urging of friends. Perhaps the new intolerance created by the wars of religion after Luther's Reformation made him cautious; perhaps, too, the astronomical arguments for the cosmological revolution were not so clear as they had been at first. Whatever the reason, Copernicus's intention was to publish only sets of astronomical tables derived from the new theory.

The *de Revolutionibus Orbium Coelestium* owes its publication to one of the most amazing scientific pilgrimages in history. A young German mathematician known as Rheticus (Georg Joachim von Lauchen (1514–76)), a Lutheran and a teacher at Wittenberg, heard of Copernicus and determined to visit him. Arriving in Varmia in the spring of 1539, he was given hospitality by Copernicus and by the Bishop of a neighbouring diocese. He stayed for two years, during which he studied Copernicus's astronomical system, and also wrote and published the first part of a non-technical description, the *Narratio Prima*. Unlike Copernicus's other friends, Rheticus was able to gain his consent to publication; and he returned to Germany with a fair copy of *de Revolutionibus* for a Nuremberg printer. But Rheticus quite suddenly found himself offered a better post at Leipzig, and so he left the supervision of the printing to a prominent theologian and man of letters, Andreas Osiander. The latter's well-meaning editorial intervention then confused the whole status and intention of Copernicus's theory. Osiander feared that philosophers and theologians would be outraged by an assertion of the heliocentric system as true; hence he inserted a prefatory note to the reader saying that it is not necessarily so, but only an hypothesis for solving problems. Copernicus saw a copy of the book shortly before he died, but he was already too ill to examine its contents. Rheticus and other friends protested bitterly at the misleading preface, but the damage could not be undone. The fruits of Copernicus's life-work, the expression of his commitment to a new cosmology, was received by his readers in 1543 as a mere reckoning device.

Thus this great revolution in human thought was conceived in obscurity during Copernicus's youth; nourished in isolation during his years of maturity and senescence; and finally launched under a misapprehension shortly after his death. The history of science has few more cruel jokes than this.

In the terms of some older conceptions of the history of science, these incidents would be only minor obstacles on the high road to Truth. The Earth's motions are a proven fact, and our task is only to give credit to those who first had the sagacity to recognise the facts as such. But as our understanding of the progress of science has matured, the historical problems of the Copernican Revolution have become more urgent and more difficult. As we consider the position of those who were opposed or doubtful concerning the motions of the Earth, we can no longer dismiss them as timid men, or reactionaries. There was no conclusive proof for Copernicus for at least a century and a half after the publication of the *de Revolutionibus*.

As an illustration of these new problems, in which the history and the philosophy of science interact closely, we have the questions: what made the young Copernicus commit himself to the truth of the theory of the Earth's motions, and was he justified in this? Certainly, all the normal sources of evidence agreed to the central position and fixity of the Earth. Only in some neo-Platonic mystical currents was there a Sun-worship that put that body at the centre of the cosmos. Doubtless Copernicus found that a Sun-centred system provided a much more coherent set of planetary motions. Also, in it several classes of phenomena were unified, notably the location, size, and timing of the 'retrograde loops' of the outer planets. But such a unification does not require the desperate measure of putting the Earth in the heavens; it is enough to have the planets' orbits centred on the Sun, itself revolving round the central Earth as ever. This was the compromise solution of Tycho Brahe (1546–1601), which had more strength in the seventeenth century than many historians have wished to admit.

Recent research has lent strength to the supposition that Copernicus's original work that led to his revolution, was on the very technical and abstruse problems of the reference frames, of angular position and time, in which mathematical astronomy was, and still is, encased. Motivation for such work would come from the ever-present scandal of the unreformed Julian calendar, and also the desire for improvement of astronomical tables. On this line, I have found it possible to reconstruct a sequence of problems leading to the stark alternatives: either the Earth rotates, or there is no hope of defining uniform motions serving as the fundamental measure of all others. The reconstruction has two disadvantages: it is very technical, and it also makes essential use of data accepted as sound by Copernicus but later recognized as spurious. This related to the supposed irregularities in the slow motions of the heavens, the so-called trepidations of the spheres mentioned by John Donne in his poem.

Turning from the obscure genesis of the Copernican theory to its confused reception, we have at least a public record of debate as a guide to the historical and methodological problems. In its early years, his system gained support among astronomers and mathematical practitioners because of the hope it offered of an improvement in astronomy. We can now look back and say that the hope was illusory. But to the astronomers of the later sixteenth century, the complete re-organization of theory and recalculation of parameters were very impressive, particularly since Copernicus had no contemporary or immediate successor commanding the same high technical competence as himself. In this phase of the Copernican revolution, the fully articulated solution of the reference-frame problems may have been of great importance. For one single period, 1717 Egyptian years (of 365 days) governed all the slow motions, on the data hopefully presented by Copernicus. And the mechanisms for these motions were not capable of a trivial translation back into geocentric terms.

By the end of the sixteenth century, the broader cosmological implications of the Copernican theory took on a life of their own. The question of the motions of the Earth was argued less and less in terms of particular quantitative theories, and increasingly by philosophical and religious considerations. As the Copernican revolution in man's conception of the cosmos got seriously under way in the seventeenth century, the particular formulation of its astronomy by Copernicus receded into the background. The debate raged through the earlier and middle seventeenth century, based on technicalities supplied by (mainly) Tycho and Kepler, with new philosophical principles provided by Galileo and Descartes.

Although no particular crucial phenomenon for Copernicus was produced during that period, still the balance of plausibility steadily shifted. The celestial dynamics of Newton (1642–1726), presupposing a central Sun as a triviality, effectively settled the question for all those who were not captive intellects in Catholic Europe. For them, there were decades of increasing embarrassment until finally their Church recognized that the issue had become harmless, and so partly repaired the damage of the Galileo affair. The ultimate arrival of undisputed observational evidence for the Copernican theory, the confirmation of stellar parallax obtained by F. W. Bessel (1784–1864), was an after-event of no great cosmological significance.

Thus if we take the origins of the Copernican Revolution to lie near the year 1500 we may speak of roughly a century for conception and announcement; another century for struggle and victory; and a third century for eventual complete acceptance. This period, or even the first two-thirds, is a very long time. Not many scientists would care to stake their careers on a theory that would take nearly two hundred years to establish! This extended duration for his revolution gives us a measure of Copernicus's daring, and of his greatness. He did not merely speculate on the motions of the Earth; he devoted his life to confirming those speculations in a scientific way. The enormity of his task could not be known to him; but as we look back on the long and tangled tale of its progress and triumph, we see why it is only just to honour Copernicus as the founder of modern astronomy, and one of the very greatest men of science.

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Uropeltid snakes—survivors in a changing world

Carl Gans

The Uropeltidae are a small group of burrowing snakes restricted to the mountains and foothills of Central India and Sri Lanka (Ceylon). They are extremely beautiful animals, showing bright pigmentation as well as physically produced iridescent colours. A pointed head and stumpy tail are among adaptations that seemingly fitted them to survival in humus of tropical montane forests. This environment is disappearing with deforestation; mainly those species that were capable of utilizing an equivalent niche in a different environment have avoided extinction.

The face of our continents is changing as the result of man's demand for ever increasing amounts of forest and agricultural products. One tends to think of the change as resulting in the destruction of giant trees and of big animals. Yet the tropical environments include untold thousands of smaller and almost unknown species, each dependent upon restricted niches that may be endangered because of our insatiable demand for plywood or charcoal, plantain or tea. In many cases, the species will have become extinct before we have more than a preliminary understanding of their biology.

Classification and structure

The 43 rough-tailed snakes belonging to the family Uropeltidae are a relict assemblage restricted to the mountains and foothills of Central India (south of Bombay to Kerala and Tamil Nadu) and Sri Lanka [1]. The only general summary of the group is that of Malcolm Smith [3], who reviewed them within the framework of the 'Fauna of British India'. He obtained much of his information from the reports of Cols. Beddome and F. Wall who assembled the best collections and furnished most of the little we know about their biology. Beyond this we have only the anatomy of one species and various bits of anatomical detail of others. Their taxonomy and detailed geographical distribution are similarly obscure: seven species are supposed to occur in the 'Nilghiri Hills', five in the 'Palni Hills', and one of the major museum collections of these animals contains about 200 specimens of which 170 are assigned simply to 'Ceylon'.

However, there have long been indications that the animals should be of interest to evolutionary biologists. The heads of these small snakes, which are 20–80 cm in length and up to 2 cm in diameter, are tiny and ridiculously pointed; the eyes are diminutive; and the lower jaw is countersunk. The nostrils are placed relatively far back and the rostral plate may bear a protruding keratinized keel. Smith comments that the neck is curved so that the axis of the head is at an angle to that of the trunk, an observation that may seemingly be confirmed in some preserved specimens. The blunt and remarkably short caudal tip ends in an enlarged shield which often bears various kinds of spines and is supported internally by a bony terminal plate, held by the enlarged neural spines of several caudal vertebrae. These burrowing animals are also described as being astonishingly beautiful. Reports refer to blacks and blues relieved by yellow, orange, and red blotches; they note blue and green iridescence, hardly a trace of which remains in specimens that have peacefully rested in alcohol for a century.

As a by-product of some other studies culminating in recent field work in association with Professor M. V. Rajendran of Tirunelveli, Madras, and Dr P. H. D. H. de Silva of Colombo, we are now beginning to unravel some of the adaptations of this curious group. One-half of the described species have been seen alive and enough data are at hand to present some new information on their biology.

The uropeltids are properly placed among the primitive snakes which include pythons and boas. They are seemingly closest to the pipe snakes or aniliids, three species of which now occur, respectively, in northern South America, eastern Asia, and Sri Lanka. Some details of the skull of the Sri Lanka species, *Cylindrophis maculatus*, suggest similarities to the uropeltid pattern. The uropeltid skull (figure 1) is elongate and comes to a point in the remarkably strengthened premaxilla which is firmly sutured to the maxillae, nasals, and vomers. The choanal ducts are curiously overroofed by bone. Smith correctly notes that the bones of the skull are more solidly united than in any other family of snakes. Only maxillae and dentaries, and sometimes the palatines, bear short, sharp teeth, similar to those seen in such worm eaters as *Calamaria*. The quadrate is relatively small and the supratemporal is little larger than the widened head of the quadrate. The lower jaw, which retains the coronoid, is remarkably stout. The brain case is firmly sutured in adults and the occipital condyle projects so far back that it was once suggested that it might incorporate part of a fused first vertebra.

The anterior vertebrae are quite elongated. Along the trunk, the vertebral column and rib basket form a unit, the anterior portion of which is quite independent of the skin. Numerous muscle slips connect each ring of scales to a vertebra. The anterior skin may then be pulled forward and backward relative to the column so that the free posterior edges of the scales overlap more or less. The axial section may even contract into a series of S-shaped curves within the integumentary envelope. This occurs particularly in the anterior part of the trunk, which then appears much thicker; only the sinuous outline of the neural spines shows that the vertebral column is curved. When the muscular contraction is severe (as in terminal convulsions) the head and anterior portion of the column may point to one side. This

Carl Gans, *B.M.E., M.S., Ph.D.*

Was born in 1923, and originally trained as a mechanical engineer; he later took a Ph.D. in biology at Harvard University. From 1947 to 1955 he dealt with construction and operation of steam generating equipment for the Babcock and Wilcox Co.; from 1953 to 1954 he worked on Brasilian reptiles as a John Simon Guggenheim Memorial Fellow. In 1958 he joined the State University of New York at Buffalo and in 1971 moved to the department of Zoology of The University of Michigan as Professor and Chairman. He specializes in biomechanics and evolutionary morphology.

Mikołaj Kopernik
1473-1543

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An exhibition commemorating the five hundredth anniversary of the birth of Nicholas Copernicus
1473 — 1973

Exposition commémorant le cinq-centième anniversaire de la naissance de Nicolas Copernic
1473 — 1973

November 28th, 1973 to February 4th, 1974
Du 28 novembre 1973 au 4 février 1974

Portrait of Copernicus from an old print
Portrait de Copernic d'après une gravure ancienne

Commemorative stamp marking the 450th anniversary of the birth of Mikołaj Kopernik issued by Poland in 1923.

Timbre commémoratif émis en Pologne en 1923 à l'occasion du 450e anniversaire de la naissance de Mikołaj Kopernik.

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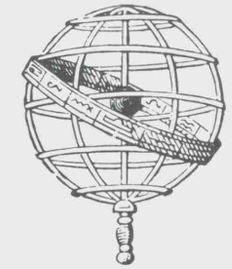

Introduction

Great men should be paid the tribute which is theirs. Every nation likes to keep alive the memory of national heroes. The greatest minds, however, belong to all of humanity whose common inheritance they have helped to enrich. Nicolaus Copernicus is such a man. This famous Pole is respected in every country. This year, on the occasion of the five hundredth anniversary of his birth, he has been honoured throughout the world. The National Library of Canada is pleased to join with numerous institutions in Canada and abroad in celebrating the importance of the scientific revolution brought about by the author of *De revolutionibus.* In departing from existing theories of astronomy, Copernicus accorded man and the earth their rightful place in the universe.

The exhibition this catalogue describes and will preserve calls to mind not only the rich and varied career of this Renaissance man who was interested in everything around him. It is as an astronomer that he is best known, but he was also a canon, a jurist, an economist, a poet and an administrator. The encyclopedic nature of his work is illustrated by the various articles assembled for this exhibition. Other items call to mind what preceded and followed him, from the geocentric theories of antiquity and the Middle Ages to more recent discoveries

Introduction

Il convient de rendre aux grands hommes les honneurs qui leur sont dus. Les peuples aiment à perpétuer la mémoire de leurs gloires nationales. Les plus grands esprits sont toutefois l'apanage de l'humanité entière dont ils ont contribué à enrichir le patrimoine commun. Nicolas Copernic est de ceux-là. Illustre Polonais, il est honoré partout. C'est pourquoi, cette année, à l'occasion du cinq-centième anniversaire de sa naissance, on lui a rendu hommage partout dans le monde. La Bibliothèque nationale du Canada est heureuse de s'associer aux nombreuses institutions qui, au pays et ailleurs, ont souligné d'une manière particulière l'importance de la révolution scientifique accomplie par l'auteur du *De revolutionibus.* En bouleversant toute l'astronomie, Copernic a situé la terre et l'homme à leur vraie place dans l'univers.

L'exposition que ce catalogue décrit et perpétuera n'évoque pas seulement la carrière riche et diverse de cet homme de la Renaissance qui s'intéressait à tout. C'est l'astronome qui est le mieux connu et le plus célébré, mais ce chanoine était aussi juriste, économiste, poète et administrateur; le caractère encyclopédique de son oeuvre est souligné par les diverses pièces qui ont été réunies pour cette exposition. D'autres pièces évoquent ce qui l'a précédé et ce qui l'a suivi, depuis les théories géocentriques de l'antiquité et du Moyen-Age jusqu'aux récentes dé-

The Reception of Copernicus' Heliocentric Theory

Proceedings of a Symposium Organized by the 'Nicolas Copernicus Committee' of the International Union of the History and Philosophy of Science, Toruń, Poland 1973

edited by
JERZY DOBRZYCKI (Polish Academy of Sciences)

1973, viii + 368 pp. LC 72–95980
Cloth Dfl. 65,– / US $ 24.00 ISBN 90–277–0311–6

This collection of 11 papers presents the most recent results of research on the struggle and the final acceptance of Copernican astronomy. The dissemination of scientific ideas, the repeated struggle for acceptance of new theories form an important element of the history of science. This is particularly true in the case of the fundamental remoulding of scientific and cultural concepts caused by the "Copernican revolution". The reception of the heliocentric theory is treated in this book by authors from nine countries, presenting 11 case-studies in progress of science and of general education. The influence of Copernicus' work on leading scientists from XVI–XVII centuries is treated in essays on Tycho Brahe, Maestlin and on the consequences of the new theory in the physical sciences. Eminent specialists investigate the reception of new astronomy in Poland, Denmark, Sweden, Norway, Great Britain, Spain, Hungary, Colonial America and Japan. Important new results in history of science in these countries are presented. Moreover the book presents documented evidence on the general regularities in the history of ideas, offering an insight into the recurrent pattern of changing attitude toward a major scientific achievement.

Contents

Foreword. – Robert S. Westman: The Comet and the Cosmos: Kepler, Mästlin and the Copernican Hypothesis. – Kristian P. Moesgaard: Copernican Influence on Tycho Brahe. – Hans Blumenberg: Die Kopernikanische Konsequenz für den Zeitbegriff. – Barbara Bieńkowska: From Negation to Acceptance (The Reception of the Heliocentric Theory in Polish Schools in the 17th and 18th Centuries). – Kristian P. Moesgaard: How Copernicanism took root in Denmark and Norway. – Shigeru Nakayama: Diffusion of Copernicanism in Japan. – John L.

p.t.o.

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The Scientific World of Copernicus

On the Occasion of the 500th Anniversary of his Birth, 1473–1973

edited by
B. BIEŃKOWSKA
(Translated from the Polish by C. Cenkalska)

1973, xii + 144 pp. LC 72–95980
Cloth Dfl. 50,– / US $ 19.50 ISBN 90–277–0353–1

This book on Copernicus deals with the whole range of his activities, and examines the numerous effects which his discoveries have had on methodology, culture, literature, philosophy and religion.
The life and work of this great Polish scientist is seen against both the background of knowledge pertaining in his time and the circles he moved in.
The discoveries of Copernicus may thus be assessed as constituting a highly significant turning point in the history of ideas.

Contents

Introduction by Z. Kopal. – S. Herbst: The Country and the World of Copernicus. – J. Dobrzycki: Nicolaus Copernicus–His Life and Work. – J. Dobrzycki: Chronicle of the Life and Work of Copernicus. – A. Birkenmajer: Astronomer of the Age of Transition. – W. Zonn: Nicolaus Copernicus–Founder of the New Astronomy. – L. Infeld: From Copernicus to Einstein. – W. Voisé: The Great Renaissance Scholar. – B. Suchodolski: The Impact of Copernicus on the Development of the Natural and the Human Sciences. – E. Lipiński: Copernicus as Economist. – B. Bieńkowska: The Heliocentric Controversy in European Culture. – Selected Copernican Bibliography, compiled by J. Dobrzycki. – Index, compiled by B. Bieńkowska.

Audience

This book can be used as supplementary reading at courses in the history of science and culture. It will be of interest to a large audience because of its general informational character.

D. REIDEL PUBLISHING COMPANY
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I would like to express my deep appreciation to the institutions and individuals who were kind enough to loan us exhibits for this occasion; a list follows. I would especially like to thank Miss Liana Van der Bellen, curator of rare books in the National Library of Canada, who kindly agreed to prepare this exhibition, select the articles for it and list them in a catalogue. She was assisted by Mr. André Preibish, Mr. Bernard Brégaint, Mr. Tom Hawkins and Mrs. Yvonne Boivin, all of whom I would like to thank.

Guy Sylvestre,
National Librarian

Je tiens à remercier vivement les institutions et les particuliers qui ont bien voulu nous prêter des pièces à l'occasion de cette exposition; on en trouvera la liste ci-après. Je veux remercier particulièrement Mlle Liana Van der Bellen, conservateur des livres rares à la Bibliothèque nationale du Canada, qui a bien voulu préparer cette exposition, en choisir les pièces et en dresser le catalogue. Elle a été aidée dans son travail par MM. André Preibish, Bernard Brégaint et Tom Hawkins et par Mme Yvonne Boivin, à qui je tiens à exprimer ici ma gratitude.

Guy Sylvestre,
Directeur général

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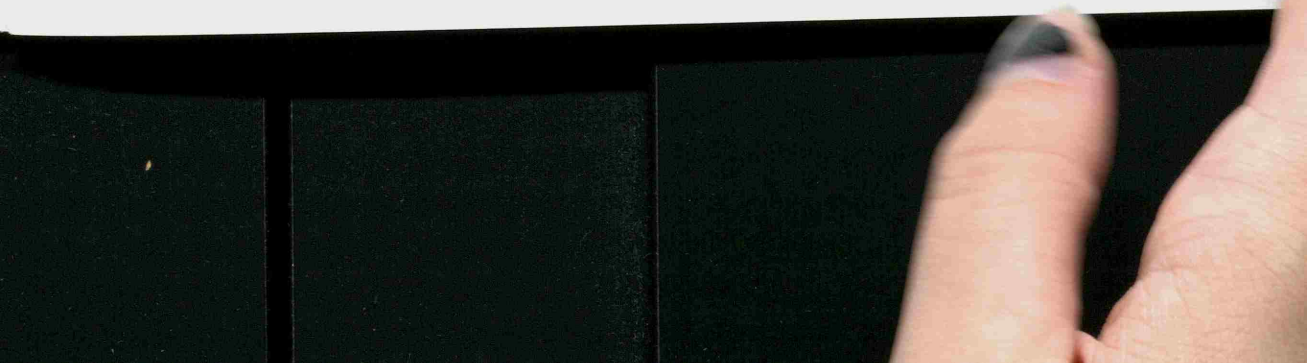
La Bibliothèque scientifique nationale

L'Université d'Ottawa

M. Henryk et M. Maciej Kozłowski

Mme Elizabeth Namiesniowski

M. Norbert Paprocki



Otto Neugebauer, *Egyptian astronomical texts.* Providence, R.I., Brown University Press, 1960.

The texts represent three major periods: those from the Ninth Dynasty are attempts to measure time by the so-called *decans* (risings and transits of stars and constellations); the second period is represented by the Ramesside monuments; the third is the Ptolemaic period in which the zodiac was introduced, to which the decans were assimilated.

To cite Neugebauer: "Egyptian astronomy was contented with a very summary qualitative description of phenomena, and lacked all traces of a scientific method . . . It is a great error to bestow upon Egyptian mathematical or astronomical documents the glorious title of scientific works, or to assume the existence of an unknown, forgotten, or secret science yet to be discovered in extant texts."

Description de l'Egypte, ou Recueil des observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'armée française, publiée par les ordres de Sa Majesté, l'empereur Napoléon le Grand. Paris, Imprimerie impériale, 1809. T. 1, *Recherches sur les bas-reliefs astronomiques des Egyptiens.*

Archaeological searches conducted during Napoleon's Egyptian campaign revealed rich sources for the study of Egyptian astronomy and astrology. Among others was discovered the famous circular zodiac of the temple at

Otto Neugebauer, *Egyptian astronomical texts.* Providence, R.I., Brown University Press, 1960.

Recueil d'anciens écrits astronomiques Egyptiens, de la IXe dynastie jusqu'à l'époque des Ptolémées.

Neugebauer dit au sujet de l'astronomie égyptienne: " . . . L'astronomie égyptienne se contentait d'une description qualitative très sommaire des phénomènes . . . C'est une erreur grave que d'accorder aux documents égyptiens, mathématiques ou astronomiques le titre glorieux d'oeuvres scientifiques . . . "

Description de l'Egypte, ou Recueil des observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'armée française, publiée par les ordres de Sa Majesté, l'empereur Napoléon le Grand. Paris, Imprimerie impériale, 1809. T. 1, *Recherches sur les bas-reliefs astronomiques des Egyptiens.*

Les résultats des fouilles archéologiques, faites pendant la campagne d'Egypte de Napoléon, furent rapportés en détail dans l'ouvrage monumental *Description de l'Egypte.* A l'époque, on croyait qu'il s'agissait de monuments astronomiques

Pierre Duhem, *Le système du monde; histoire des doctrines cosmologiques de Platon à Copernic.* Paris, Hermann, 1954-1973. 10 v.

One of the most important studies on Greek and mediaeval astronomy and cosmology.

The School of Athens, fresco by Raphael, Stanza della Segnatura, the Vatican. In *The age of the Renaissance.* London, Thames & Hudson, 1967.

This composition, an imaginary assembly of Greek philosophers of various periods shows, among others, Plato and Aristotle (centre) Pythagoras (left foreground) and Ptolemy (on the right, holding up a terrestrial and a celestial globe).

Pythagoras (fl. 530 B.C.) was one of the first exponents of the idea of a spherical universe. To him, as to Plato and Aristotle, the earth was a sphere, stationary in the centre of a finite, spherical universe. The heavenly bodies moved around it on circular orbits. Eudoxus (408-355 B.C.), a disciple of Plato, explained the motions of the moon and the planets by means of concentric spheres, each rotating about an axis fixed in the one outside it, thus setting the tradition of homocentric (and transparent) spheres.

Pierre Duhem, *Le système du monde; histoire des doctrines cosmologiques de Platon à Copernic.* Paris, Hermann, 1954-1973. 10 v.

Ouvrage fondamental sur la conception de l'univers des philosophes grecs et au Moyen - Age.

L'école d'Athènes, fresque de Raphaël, Stanza della Segnatura, Vatican. Dans *The age of the Renaissance.* London, Thames & Hudson, 1967.

Cette peinture, une assemblée des philosophes grecs de diverses époques, montre entre autres Platon et Aristote (au centre), Pythagore (à gauche, en train d'écrire), et Ptolémée, tenant dans ses mains un globe terrestre et un globe céleste.

Pythagore fut un des premiers philosophes grecs à proposer l'hypothèse d'une terre sphérique, immobile, au centre d'un monde formé de sphères concentriques tournant autour d'elle. Platon et Aristote adoptent cette théorie. Eudoxe, disciple de Platon, s'attaque au problème des mouvements planétaires. Il introduit sa théorie des sphères homocentriques tournant à des vitesses différentes autour d'axes différemment inclinés.

sun. Aristarchos' only surviving treatise concerns the sizes and distances of the sun and the moon.

Ptolemy (2d century B.C.) Almagest. In *Great books of the Western world.* Chicago, Encyclopaedia Britannica, 1952. v. 16.

This synthesis of ancient Greek scientific thought is the earliest surviving treatise of mathematical astronomy. It includes the results of Ptolemy's own observations and research as well as those of earlier Alexandrian astronomers, principally Apollonius of Perga (250-180 B.C.), who introduced the theory of epicycles and deferents as an alternative to the spheres of Eudoxus; and Hipparchus (190-120 B.C.), the greatest observational astronomer of antiquity and compiler of the first star catalogue. Ptolemy himself established a working mathematical model by which positions of the planets could be predicted with relative accuracy.

observations nous ont été transmises par Archimède. Le seul des ouvrages d'Aristarque qui nous est parvenu est son *Traité des grandeurs et des distances du soleil et de la lune.*

Ptolémée (IIe siècle ap. J.-Chr.) Almageste, dans *Great books of the Western world.* Chicago, Encyclopaedia Britannica, 1952. v. 16.

L'Almageste, le manuel le plus ancien d'astronomie mathématique, est une synthèse de la pensée astronomique grecque. Il comporte le résultat des observations et des recherches de Ptolémée et de ses prédécesseurs au Musée d'Alexandrie: Apollonius (250-180) qui substitua aux sphères compensatrices d'Eudoxe les épicycles et les déférents, et Hipparque (190-120), à qui on doit le premier catalogue d'étoiles.

Joannes de Sacro Bosco (John of Holywood, fl. 1230), *Opus sphaericum.* Venetiis, Georgius de Monteferrato, 1500.

Before the invention of printing, many manuscript copies were made of this popular mediaeval astronomy manual by the English mathematician who taught for a long time in Paris.

Joannes de Sacro Bosco (John of Holywood, fl. 1230), *Opus sphaericum.* Venetiis, Georgius de Monteferrato, 1500.

Le manuel d'astronomie de Jean de Holywood, mathématicien anglais qui enseigna à Paris, connut une très grande vogue au Moyen-Age.

Nicole Oresme (1348-1382)

Nicole Oresme working at his desk beside an armillary sphere. (From a 15th century French manuscript at the Bibliothèque nationale, Paris). In *A general history of the sciences,* edited by René Taton, v. 1.

In his *Livre du ciel et du monde,* a commentary on Aristotle's *De coelo,* written in 1377 for Charles V of France, the mediaeval mathematician and churchman speculates on the possibilities of a rotating earth.

Nicole Oresme (1348-1382)

Nicole Oresme travaillant à son pupitre à côté d'une sphère armillaire. (Ms français du XVe siècle à la Bibliothèque nationale de Paris).Dans *A general history of the sciences,* éd. par René Taton, v. 1.

Dans son *Livre du ciel et du monde,* commentaire sur *De coelo* d'Aristote, écrit à la demande du roi Charles V, le savant évêque de Lisieux discute l'hypothèse de la rotation de la terre.

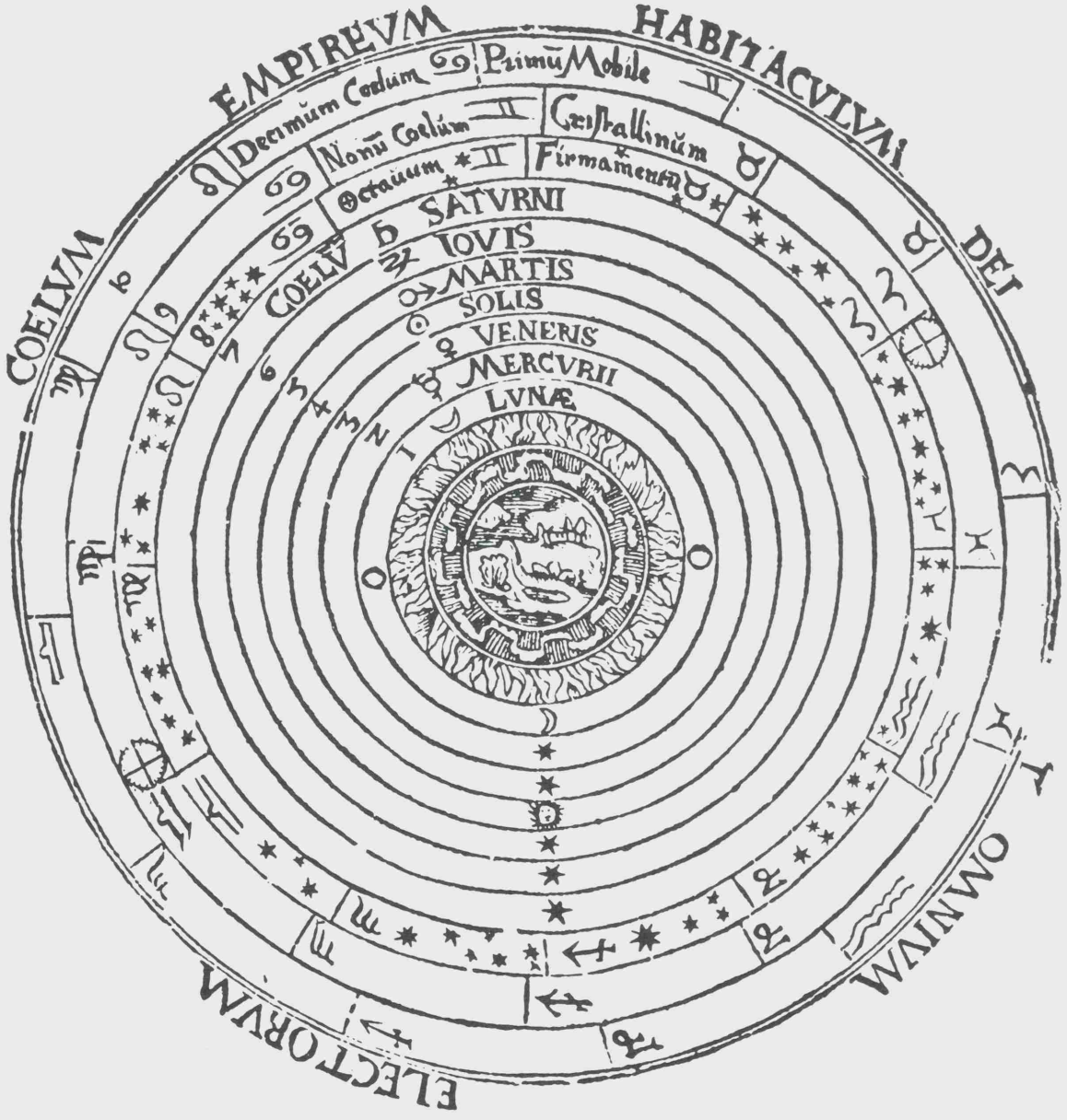
Nicolaus Cusanus (1401-1464) *Opera.* Paris, Badius Ascencius, 1514. (Facsimile).
Giuseppe Bufo, *Nicolas de Cues, ou la métaphysique de la finitude.* Paris, Seghers, 1964.

"An important chapter in the history of cosmology was written when Nicholas of Cusa challenged the classical conception of a closed and hierarchical universe. As against this cosmology which held sway for almost two thousand years, he introduced a universe of which the centre is everywhere and the circumference nowhere." (*A general history of the sciences,* ed. by René Taton, v. 1, p. 52).

Nicolaus Cusanus (1401-1464) *Opera.* Paris, Badius Ascencius, 1514. (Fac-similé).
Giuseppe Bufo, *Nicolas de Cues, ou la métaphysique de la finitude.* Paris, Seghers, 1964.

"Dans l'histoire de la pensée cosmologique, l'oeuvre de Nicolas de Cues occupe une place de toute première importance. Pour la première fois en effet, la conception classique d'un monde clos et hiérarchiquement ordonné, qui a dominé la pensée humaine pendant à peu près 2000 ans, y fut attaquée au profit de celle d'un monde ouvert . . . d'un monde 'dont le centre est partout, et la circonférence, nulle part.'" (*Histoire générale des sciences,* t. 1, p. 52).

Figure de la diuision des Spheres.



Professor of astronomy at the University of Ingolstadt in Southern Germany, Petrus Apianus or Peter Bienewitz is the author of scientific works, many of which he printed himself. Some of his books contain paper astronomical instruments with movable parts. The illustration and description above show a typical view of the universe at the beginning of the 16th century. His *Cosmographicus liber* of which this is a French translation, first came out in 1524.

Copernicus: the man and his work

Mikołaj Kopernik, 1473-1543. The anonymous 16th century portrait in the Torun District Museum.

Poland
Novissima Poloniae regni descriptio. Map by Jansson in *The English Atlas.* Oxford, Printed at the Theatre for Joh. Jansonius a Waesberge and Steven Swart, Booksellers in Amsterdam, 1680.

This map is one of twenty copies of a facsimile reprint made in 1943 for O. Halecki, the owner of the rare original edition of this atlas, and was given by him to W.L. Mackenzie King, then Prime Minister of Canada.

Professeur d'astronomie à l'Université d'Ingolstadt dans le sud de l'Allemagne, Petrus Apianus ou Peter Bienewitz est l'auteur de plusieurs ouvrages scientifiques qu'il imprima lui-même. Dans quelques-uns de ses livres, on trouve des instruments astronomiques en papier, dotés de pièces mobiles. Son *Cosmographicus liber* (1524), dont on voit ici la traduction française, représente le point de vue traditionnel en astronomie.

Copernic: l'homme et son oeuvre

Mikołaj Kopernik, 1473-1543. Portrait anonyme de Copernic au Musée de Torun.

La Pologne
Novissima Poloniae regni descriptio. Carte de Jansson dans *The English Atlas.* Oxford, Printed at the Theatre for Joh. Jansonius a Waesberge and Steven Swart, Booksellers in Amsterdam, 1680.

Cette carte est une réimpression en fac-similé reproduite en vingt exemplaires pour O. Halecki, le propriétaire de l'édition originale de l'atlas, en 1943. L'exemplaire de la Bibliothèque nationale fut offert par M. Halecki à W.L. Mackenzie King, alors Premier Ministre du Canada.

The towns of Copernicus

Jan Adamczewski, *The towns of Copernicus.* Warsaw, Interpress Publishers, 1972.

Toruń

Henryk Bietkowski and Włodzimierz Zonn, *The world of Copernicus.* Warsaw, Arkady Publishers, 1973.

The birth-place of Copernicus. He was born on February 19, 1473, the fourth child of the well-to-do merchant Mikołaj Kopernik and his wife Barbara Watzenrode

Genealogy of Copernicus. In Eugeniusz [and] Prezemysław Rybka, *Kopernik: człowiek i myśl.* Warszawa, Wiedza Powszechna, 1972.

Birth-place and family of Copernicus.

Karol Górski, *Dom i środowisko rodzinne Mikołaja Kopernika.* Toruń, Towarzystwo Naukowe w Toruniu, 1972.

View of the home of the Copernicus family.

Janina Mazurkiewicz, *Kopernikana Toruńskie.* Toruń, Wojewódzki Komitet Kultury Fizycznej i Turystyki, 1972.

Bohdan Rymaszewski, *Torun in the days of Copernicus; urban development, architecture, art.* Toruń, Towarzystwo Naukowe w Toruniu, 1973.

Rocznik Toruński, 7. Toruń, Towarzystwo Miłośników Torunia, 1972.

Torun Yearbook, published by the Society of the Friends of Torun.

Les villes de Copernic

Jan Adamczewski, *The towns of Copernicus.* Warsaw, Interpress Publishers, 1972.

Toruń

Henryk Bietkowski et Włodzimierz Zonn, *The world of Copernicus.* Warsaw, Arkady Publishers, 1973.

La ville natale de Copernic. Quatrième enfant du riche marchand Mikołaj Kopernik et de sa femme Barbara Watzenrode, il est né le 19 février 1473.

Généalogie de Copernic, dans Eugeniusz [et] Przemysław Rybka, *Kopernik: człowiek i myśl.* Warszawa, Wiedza Powszechna, 1972.

La maison natale et la famille de Copernic.

Karol Górski, *Dom i środowisko rodzinne Mikołaja Kopernika.* Toruń, Towarystwo Naukowe w Toruniu, 1972.

Maison familiale des Copernic.

Janina Mazurkiewicz, *Kopernicana Toruńskie.* Toruń, Wojewódzki Komitet Kultury Fizycznej i Turystyki, 1972.

Bohdan Rymaszewski, *Torun in the days of Copernicus; urban development, architecture, art.* Toruń, Towarzystwo Naukowe w Toruniu, 1973.

Rocznik Toruński, 7. Toruń, Towarzystwo Miłośników Torunia, 1972.

Annuaire de la ville de Torun, consacré aux études coperniciennes et publié par la Société des amis de Torun.

The Alma Mater of Copernicus has many priceless objects and documents in its possession: the original manuscript of *De revolutionibus*; the matriculation record of Copernicus; books and manuscripts of the 15th and 16th centuries; astronomical instruments and celestial globes; portraits and statues of Copernicus.

Jerzy Marek Kreiner, *Obserwatorium astronomiczne Uniwersytetu Jagiellońskiego.* Kraków, Nakładem Uniwersytetu Jagiellońskiego, 1972.

The observatory of the Jagellonian University at Cracow

Bologna
In 1496, his uncle Bishop Lucas Watzenrode sent Copernicus to Bologna to study Canon Law at the famous University. On his way, he is supposed to have visited the observatory at Hamburg which had been set up by Bernhard Walther for his teacher Regiomontanus. At Bologna, Copernicus was greatly influenced by the professor of astronomy Domenico Maria de Novara (1454-1504), at whose house he is said to have lodged.

View of Bologna

Hartmann Schedel, *Liber chronicarum.* Nürnberg, Anton Koberger, 1493.

L'Alma mater de Copernic possède un grand nombre d'objets et de documents d'intérêt copernicien: l'inscription de Copernic à l'université; le manuscrit original de *De revolutionibus;* instruments astronomiques et globes célestes; portraits et statues de Copernic; manuscrits et imprimés des XIVe et XVe siècles.

Jerzy Marek Kreiner, *Obserwatorium astronomiczne Uniwersytetu Jagiellońskiego.* Kraków, Nakładem Uniwersytetu Jagiellońskiego, 1972.

L'observatoire de l'Université Jagelonne à Cracovie

Bologne
En 1496, Copernic fut envoyé à Bologne par son oncle Lucas Watzenrode, évêque de Warmie, afin qu'il puisse étudier le droit canon à la célèbre université. On croit qu'il visita Hambourg en chemin, et qu'il examina l'observatoire que Bernhard Walther avait fait construire pour son maître Regiomontanus. A Bologne, il subit l'influence de Domenico Maria de Novara (1454-1504), le professeur d'astronomie. Quelques biographes croient qu'il habita chez Novara au cours de son séjour à Bologne.

Vue de Bologne

Hartmann Schedel, *Liber chronicarum.* Nürnberg, Anton Koberger, 1493.

Ferrara
Copernicus received his Doctorate in Canon Law at this University in 1503. It is assumed that he preferred to go through the solemn graduation ceremonies here rather than at Padua for reasons of economy.

View of Ferrara

Hartmann Schedel, *Liber chronicarum.* Nürnberg, Anton Koberger, 1493.

Lidzbark
In 1503, having returned to Poland for good, Copernicus assumed his tasks as one of the Canons of the Warmian Chapter. At the same time, he acted as secretary and personal physician to his uncle, Lucas Watzenrode, Bishop of Warmia since 1489. He resided at the Castle of Lidzbark.

Views of the Warmian Episcopal Castle

Henryk Bietkowski and Włodzimierz Zonn, *The world of Copernicus.* Warsaw, Arkady, 1973.

Olsztyn
As administrator of the capitular estates of Warmia, Copernicus resided at the fortified castle of Olsztyn, on occasion having to supervise the defence of the town against the Teutonic Order.

Views of Olsztyn

Henryk Bietkowski and Włodzimierz Zonn, *The world of Copernicus.* Warsaw, Arkady, 1973.

Ferrare
C'est en 1503, à l'Université de Ferrare, que Copernic obtint son doctorat en droit canon. Quelques biographes supposent qu'il s'est présenté à la collation des grades de cette université, plutôt qu'à Padoue, pour des raisons d'économie.

Vue de Ferrare

Hartmann Schedel, *Liber chronicarum.* Nürnberg, Anton Koberger, 1493.

Lidzbark
En 1503, de retour en Pologne, Copernic devient l'un des chanoines du Chapitre de Warmie. Il est aussi secrétaire et médecin personnel de son oncle, évêque de Warmie depuis 1489. Ils résident au château de Lidzbark.

Vues du château de l'évêque de Warmie

Henryk Bietkowski et Włodzimierz Zonn, *The world of Copernicus.* Warsaw, Arkady, 1973.

Olsztyn
Comme administrateur des domaines du chapitre de Warmie, Copernic résida de temps en temps au château fort d'Olsztyn. Durant le siège d'Olsztyn par l'Ordre Teutonique, il fut chargé de la défense du château.

Vues de Olsztyn

Henryk Bietkowski et Włodzimierz Zonn, *The world of Copernicus.* Warsaw, Arkady, 1973.

The library of Copernicus

Leonard Jarzebowski, *Biblioteka Mikołaja Kopernika.* Toruń, Towarzystwo Naukowe w Toruniu, 1971.

Photograph by Magdalena Rusinek-Kurilecka. In *Land of Copernicus.* Warsaw, Sport i Turystyka, 1973.

Most of the books as well other documents which belonged to Copernicus were sent to Sweden during the Thirty Years War, when the Swedes occupied parts of Poland (1626). As a result, many of his books are today at the library of the University of Uppsala. In his collection were, among others, a Greek and a Latin edition of the *Almagest,* the Alphonsine Tables, prepared for the Castilian King Alfonso X by a group of astronomers in 1252, and the works of Euclid, Regiomontanus, and Apianus.

Works of Copernicus

Copernicus, literary scholar and poet

The first work of Copernicus to appear in print was a translation of a collection of epistles in verse form of the Byzantine poet Theophylactus Simocatta (7th century A.D.). The work was printed in Cracow by Jan Haller in 1509 and was dedicated to the uncle of Copernicus.

Title page. In *The Land of Copernicus,* p. 160.

La bibliothèque de Copernic

Leonard Jarzebowski, *Biblioteka Mikołaja Kopernika,* Toruń, Towarzystwo Naukowe w Toruniu, 1971.

Photographie par Magdalena Rusinek-Kurilecka. Dans *Land of Copernicus.* Warsaw, Sport i Turystyka, 1973.

La plupart des livres et des autres documents ayant appartenu à Copernic furent emportés en Suède pendant la Guerre de Trente ans (1618-1648). Ainsi, plusieurs de ses livres se trouvent aujourd'hui à la bibliothèque de l'Université d'Uppsala. Parmi ces volumes, il y avait une édition en langue grecque et une édition latine de l'*Almageste,* Les Tables alphonsines, compilées pour le roi Alphonse le Sage de Castille par un groupe d'astronomes, en 1252, les oeuvres d'Euclide, de Regiomontanus, d'Apiane, etc.

Oeuvres de Copernic

Copernic, homme de lettres et poète

Le premier ouvrage à être publié fut une collection d'épîtres en vers du poète byzantin du VIIe siècle, Theophylactus Simocatta, que Copernic traduisit en latin. L'ouvrage fut imprimé en 1509 par Jan Haller, à Cracovie. Copernic le dédia à son oncle, l'évêque.

Page de titre, dans *The Land of Copernicus,* p. 160.

When inflation threatened Poland following the armistice with the Teutonic Order, Copernicus made some studies on currency reform. His report on the subject, *Monetae cudendae ratio,* is considered by Taylor as one of the "great milestones in the progress of economic thought."

Commentariolus

Nicolai Coppernici de hypothesibus motuum coelestium a se constitutis commentariolus. In Leopold Prowe, *Nicolaus Copernicus.* Osnabrück, Otto Zeller, 1967. (Reprint of 1883-1884 ed.) p. 172-202.

Three Copernican treatises: The Commentariolus of Copernicus. The Letter against Werner. The Narratio prima of Rheticus. Translated, with introduction, notes and bibliography by Edward Rosen. New York, Dover, 1959.

Copernicus circulated a brief outline known as the *Commentariolus,* of his heliocentric theories among a few fellow scientists and friends. It appears that in 1533 the secretary to Pope Clement VII read the paper to his patron who received it favourably. It appeared in print for the first time at the end of the 19th century.

Epistola Coppernici contra Wernerum

Johannes Werner, a German mathematician, published in 1522 in Nuremberg a collection of papers on mathematics and astronomy. The paper *De motu octavae sphaerae tractatus primus* was sent to Copernicus for comments by his

Après l'armistice avec l'Ordre Teutonique, la Pologne fut menacée par l'inflation. Copernic proposa des réformes monétaires dans son traité *Monetae cudendae ratio,* considéré par Taylor comme un témoignage important du progrès de la pensée économique au XVIe siècle.

Commentariolus

Nicolai Coppernici de hypothesibus motuum coelestium a se constitutis commentariolus. Dans Leopold Prowe, *Nicolaus Coppernicus.* Osnabrück, Otto Zeller, 1967. (Réimpression de l'édition de 1883-1884) p. 172-202.

Three Copernican treatises: The Commentariolus of Copernicus. The Letter against Werner. The Narratio prima of Rheticus. Translated, with introduction, notes and bibliography by Edward Rosen. New York, Dover, 1959.

Copernic communiqua une version abrégée de ses théories héliocentristes à quelques hommes de science et amis. Ce document manuscrit est connu sous le titre de *Commentariolus.* Il fut publié pour la première fois vers la fin du XIXe siècle.

Epistola Coppernici contra Wernerum

Johannes Werner, mathématicien allemand, publia en 1522, à Nuremberg, une collection de traités astronomiques et mathématiques. Son ami Bernard Wapowski, secrétaire du roi de Pologne expédia à Copernic un de ses écrits,

Rheticus

Karl Burmeister, *Georg Joachim Rheticus,* 1514-1574. Wiesbaden, Guido Pressler Verlag, 1968.

When Rheticus arrived at Frombork at the age of twenty-five, he was already well-known as astronomer and mathematician. He had studied at Zurich, Wittenberg, Nuremberg and Tübingen and was at the time professor at the University of Wittenberg. After studying for two years with Copernicus, he returned to his former teaching post. He later taught at Leipzig. Rheticus is the author and editor of many scientific works.

De lateribus et angulis triangulorum

In 1542, Copernicus published his treatise on trigonometry *De lateribus et angulis triangulorum.* It was printed at Wittenberg by Johannes Luft. Later, it formed part of *De revolutionibus.*

Rheticus

Karl Burmeister, *Georg Joachim Rheticus,* 1514-1574. Wiesbaden, Guido Pressler Verlag, 1968.

Quand Rheticus se rendit à Frombork, il était déjà bien connu comme mathématicien et astronome malgré son jeune âge. Après avoir étudié aux universités de Zurich, de Wittenberg, de Nuremberg et de Tubingen, il enseigna à l'université luthérienne de Wittenberg. Après avoir passé deux ans avec Copernic, il retourna à son ancien poste à Wittenberg. Plus tard, il enseigna à Leipzig. Rheticus est l'auteur de plusieurs ouvrages scientifiques.

De lateribus et angulis triangulorum

En 1542, Copernic publia son traité de trigonométrie, sous le titre *De lateribus et angulis triangulorum.* L'ouvrage fut imprimé à Wittenberg par Johannes Luft. Plus tard, ce texte fut inclus dans *De revolutionibus* .

Facsimile of the title-page of *De revolutionibus*, 1543.

Fac-similé de la page de titre de *De revolutionibus*, 1543.

De revolutionibus

De revolutionibus orbium coelestium. (Facsimile of manuscript). London, Macmillan & Polish Scientific Publishers, 1972.

This is a reproduction of Copernicus' own copy of the original manuscript. Rheticus is assumed to have taken another copy to the printer, but it is lost. Copernicus left his personal copy to Rheticus. After the death of the latter, it passed through several hands. At one time it belonged to the great Bohemian scholar Jan Amos Comenius. For over 150 years, it was in the library of the Nostic family in Prague. It was given by the Czech government to Poland in 1956, and is now at the Jagellonian Library in Cracow.

De revolutionibus orbium coelestium. Norimbergae, Apud Joh. Petreium, 1543. (Facsimile).

In 1541, Rheticus took the manuscript to Nuremberg to have it printed by Johannes Petreius, and entrusted the supervision of the work to his old tutor Johannes Schöner and to Andreas Osiander, a Lutheran theologian and mathematician. Osiander wrote the anonymous and apologetic preface to the book. The printing was finished towards the end of March 1543, shortly before Copernicus' death, which occurred on the 24th of May. Some historians assume that he saw the printed volume before he died. A second

De revolutionibus

De revolutionibus orbium coelestium. Fac-similé du manuscrit. London, Macmillan & Polish Scientific Publishers, 1972.

Ce fac-similé fut reproduit d'après le seul manuscrit existant de *De revolutionibus.* On croit que Rheticus en donna une copie à l'imprimeur, mais cet exemplaire est perdu. Copernic légua sa propre copie à Rheticus. Après la mort de ce dernier, le manuscrit a appartenu à diverses personnes, entre autres au célèbre savant bohémien, Jan Amos Comenius. Pendant plus d'un siècle, il fit partie de la bibliothèque des comtes de Nostic à Prague. En 1956, le gouvernement de la Tchécoslovaquie l'offrit à la Pologne. Il se trouve aujourd'hui à la Bibliothèque jagelonne de l'Université de Cracovie.

De revolutionibus orbium coelestium. Norimbergae, Apud Joh. Petreium, 1543. (Fac-similé).

En 1541, Rheticus apporta le manuscrit chez l'imprimeur Johannes Petreius, à Nuremberg, et confia la surveillance du travail à son ancien maître Johannes Schöner et à Andreas Osiander, un théologien luthérien et mathématicien. Osiander rédigea la note anonyme adressée au lecteur, dans laquelle il tâche de minimiser la hardiesse des idées de l'auteur. L'impression fut achevée vers la fin de mars 1543, peu de temps avant la mort de Copernic, le 24 mai.
Quelques historiens maintiennent que Copernic vit le volume avant de mourir.

Alojzy Tujakowski, *Mikołaja Kopernika "De revolutionibus", historia wydań,* Toruń, Towarzystwo Naukowe w Toruniu, 1973.

A study on the publishing of *De revolutionibus*

Copernicus' remarks on his work

Exerpt from the preface of De revolutionibus, dedicated to Pope Paul III:

"I may well presume, most Holy Father, that certain people, as soon as they hear that in this book about the Revolutions of the Spheres of the Universe, I ascribe movement to the earthly globe, will cry out that, holding such views I should at once be [condemned] . . . Thinking therefore within myself that to ascribe movement to the Earth must indeed seem an absurd performance on my part to those who know that many centuries have consented to the establishment of the contrary judgement, namely that the Earth is placed immovably as the central point in the middle of the Universe. I hesitated long whether . . . I should give to the light these my commentaries written to prove the earth's motion . . ." (*Land of Nicholas Copernicus,* p. 45)

Alojzy Tujakowski, *Mikołaja Kopernika "De revolutionibus"; historia wydań,* Toruń, Towarzystwo Naukowe w Toruniu, 1973.

Etude sur la publication de *De revolutionibus*

Ce que dit Copernic sur son oeuvre

Au très Saint Père le Pape Paul III. Préface de Nicolas Copernicus aux Livres des révolutions, dans *Des révolutions des orbes célestes.* Introduction, traduction et notes de A. Koyré. Paris, A. Blanchard, 1970.

"Je puis fort bien m'imaginer, Très Saint Père, que, dès que certains gens sauront que, dans ces livres que j'ai écrits sur les révolutions des sphères du monde, j'attribue à la terre certains mouvements, ils clameront qu'il faut tout de suite nous condamner, moi et cette mienne opinion . . . [considérée absurde par] ceux qui savent être confirmée par le jugement des siècles l'opinion que la terre est immobile au milieu du ciel comme son centre, si par contre j'affirme que la terre se meut . . . je me demandais longuement si je devais faire paraître mes commentaires, écrits pour la démonstration de son mouvement . . ."

17th centuries. *De revolutionibus* was placed on the Index in 1616 and stayed there until the end of the 18th century.

Copernicus: the complete works

Dziela wszystkie. Warszawa-Kraków, Państwowe Wydawnictwo Naukowe, 1972, v. 1.

The first volume of a critical definitive edition of the complete works of Copernicus, published in Poland in 1972.

Studies on Copernicus and his work

Marian Biskup, *Regesta copernicana.* Wrocław, Zakład Narodowy Imienia Ossolińskich, 1973.

The compiler of this bibliography of 515 manuscripts and printed documents dating from 1448 to 1550 has attempted to list all important source materials for the study of the life and activities of Copernicus.

Leopold Prowe, *Nicolaus Coppernicus,* Osnabrück, O. Zeller, 1967, 3 v. (Reprint of 1883-84 edition).

One of the most scholarly biographies of Copernicus. It includes texts of some of his shorter works, *Narratio prima, Commentariolus* etc. The first biography of Copernicus was written by Rheticus, but it is lost.

1616 que *De revolutionibus* fut mis à l'index. Il y resta jusqu'à la fin du XVIIIe siècle

Copernic: les oeuvres complètes

Dziela wszystkie. Warszawa-Kraków, Państwowe Wydawnictwo Naukowe, 1972, v. 1.

Premier volume de l'édition définitive des oeuvres de Copernic, publié en Pologne en 1972.

Etudes sur Copernic et son oeuvre

Marian Biskup, *Regesta copernicana.* Wrocław, Zakład Narodowy Imienia Ossolińskich, 1973.

Ce volume répertorie "d'une manière exhaustive les sources relatives à la biographie et les activités de Copernic". Il décrit 515 documents manuscrits et imprimés couvrant les années 1448-1550, et provenant des dépôts d'archives en Pologne, en Allemagne, en Italie et en Suède.

Leopold Prowe, *Nicolaus Coppernicus,* Osnabrück, O. Zeller, 1967. 3 v. (Réimpression de l'édition de 1883-84).

Une des biographies les plus érudites de Copernic. L'auteur a inclus quelques textes de Copernic, notamment *Narratio prima* et *Commentariolus*. Ce fut Rheticus qui rédigea la première biographie de son maître, mais elle est perdue.

Alexandre Koyré, *La révolution astronomique: Copernic, Kepler, Borelli.* Paris, Hermann, 1961.

Alexandre Koyré, *La révolution astronomique: Copernic, Kepler, Borelli.* Paris, Hermann, 1961.

"En fait, la révolution astronomique s'accomplit en trois étapes, liées chacune à l'oeuvre d'un homme: avec Copernic, qui arrête le soleil et lance la terre dans les cieux, l'héliocentrisme se substitue au géocentrisme. Avec Kepler, la dynamique céleste — hélas, aristotélicienne — remplace la cinématique des cercles et des sphères de Copernic et des Anciens. De ce fait même la hantise de la circularité se trouve partiellement . . . surmontée et 'l'astronomie élliptique' fait son entrée triomphale dans le monde. Enfin, avec Borelli, dans un monde désormais ouvert et régi par la dynamique, s'achève l'unification de la physique céleste et de la physique terrestre qui se traduit par la déroute du cercle au profit de la droite infinie." (p. 10)

Thomas S. Kuhn, *The Copernican revolution; planetary astronomy in the development of Western thought.* Cambridge, Mass., Harvard University Press, 1957.

Thomas S. Kuhn. *La révolution copernicienne.* Traduit de l'anglais. Paris, Fayard, 1973.

The Copernican revolution transformed mathematical astronomy, but also effected changes in cosmology, physics, philosophy and the religious outlook.

"Bien que le mot révolution soit au singulier, l'événement fut multiple. Son noyau était une transformation de l'astronomie mathématique, mais qui embrassait des changements d'ordre conceptuel en cosmologie, en physique, en philosophie aussi bien qu'en matière de religion . . ."

Domenico Berti, *Copernico e le vicende del sistema copernicano in Italia (1550-1650)* Roma, B.B. Paravia, 1876.

Domenico Berti, *Copernico e le vicende del sistema copernicano in Italia (1550-1650)* Roma, G. B. Paravia, 1876.

The Copernican system in Italy.

Le système copernicien en Italie.

Eugeniusz Rybka, *Cztery wieki rozwoju myśli kopernikańskiej*. Warszawa, Państwowe Wydawnictwo Naukowe, 1972.

Four hundred years of Copernican heritage.

Włodzimierz Zonn, *Rewolucja kopernikańska*. Warszawa, Iskry, 1972.

The Copernican revolution.

Jerzy Broszkiewicz, Samotny podróżny. Warszawa, Iskry, 1973.

Fictional biography of Copernicus.

Jean-Claude Pecker, "The man who set the world a-spinning, or Copernicus as told to children", *The Unesco Courrier*, April 1973.

A selection of commemorative Polish stamps

Modern Astronomy and Cosmology

It took a long time for the heliocentric system outlined by Copernicus in his *De revolutionibus* to be universally accepted. Kepler, Galileo and other scientists and philosophers adopted his ideas and defended them in their writings. Opposition came from the conservative academic circles which still adhered to Aristotelian physics and the teaching of Ptolemy on planetary motions. Some scientists reserved opinion while searching for proof of the validity of Copernican theories. Religious authorities found his

Eugeniusz Rybka, *Cztery wieki rozwoju myśli kopernikańskiej*. Warszawa, Państwowe Wydawnictwo Naukowe, 1972.

La diffusion de la pensée copernicienne au cours de quatre siècles.

Włodzimierz Zonn, *Rewolucja kopernikańska*. Warszawa, Iskry, 1972.

La révolution copernicienne.

Jerzy Broszkiewicz, *Samotny podróżny*. Warszawa, Iskry, 1973.

Biographie romancée de Copernic.

Jean-Claude Pecker, "Comment la terre se mit à tourner autour du soleil, ou Copernic raconté aux enfants", *Le Courrier de l'Unesco*, avril 1973.

Quelques timbres-poste commémoratifs polonais

Astronomie et cosmologie modernes

Le système héliocentriste de l'univers, tel que le préconise Copernic dans *De revolutionibus*, ne fut pas accepté tout de suite. Bien sûr, d'éminents astronomes, entre autres Kepler et Galilée, adhèrent à ses théories et les défendent dans leurs écrits. Les universités, à quelques exceptions près, continuent à enseigner l'astronomie selon Aristote et Ptolémée. P.-H. Michel énumère quelques points sur lesquels portaient les controverses: "Géocentrisme ou héliocentrisme, immobilité ou mouvement de la terre, mouvement des planètes, monde clos ou

Rudolph II. His successor at this post, Johannes Kepler, continued his work, and on the basis of Brahe's observations published his planetary tables and star catalogue, the *Tabulae Rudolphinae.*

Johannes Kepler (1571-1630)

Mysterium cosmographicum. In *Gesammelte Werke,* München, C.H. Beck, 1937-1969.

One of the first professional astronomers to adher publicly to the Copernican system, Kepler explained his reasons for doing so in the introduction to his *Mysterium cosmographicum* (1596). In this work he also describes his idea of representing the space between the spheres of the planets by one of the five regular geometrical solids (the cube, the tetrahedron, etc.)

Kepler's greatest discovery was the disproval of the ancient idea of circular movements of the heavenly bodies. He showed that they move along elliptical orbits, according to precise mathematical rules. The results of his researches on the elliptical orbits are set down in the first two of his three laws on planetary motions, and published in his *Astronomia nova* (1609).

Harmonices mundi. Lincii Austriae, 1619.

Kepler considered *The harmony of the universe* his greatest work. He believed that this harmony existed in

de ses recherches et publia, sous le titre de *Tabulae Rudolphinae,* les tables planétaires et le catalogue des astres laissés inachevés par Brahe.

Johannes Kepler (1571-1630)

Mysterium cosmographicum. Dans *Gesammelte Werke,* München, C.H. Beck, 1937-1969.

Kepler fut un des premiers astronomes de profession à se déclarer publiquement en faveur du système copernicien. Il explique ses raisons dans l'introduction de son ouvrage *Mysterium cosmographicum* (1596). Dans ce livre, il propose aussi de représenter l'espace entre les sphères concentriques sur lesquelles les planètes se meuvent, sous forme de polyèdres tels que le cube, le tetraèdre, etc.

La plus grande découverte de Kepler fut sa théorie des orbites, en forme d'ellipse des planètes. Dans *Astronomia nova,* il énonce les deux premières de ses trois lois sur les mouvements planétaires.

Harmonices mundi. Lincii Austriae, 1619.

Dans cet ouvrage, qu'il considérait comme son oeuvre la plus importante, Kepler énonce sa troisième loi qui associe les

I have not dared to bring into the public light, frightened by the fate of Copernicus himself, our teacher, who, though he acquired immortal fame with some, is yet to an infinite multitude of others (for such is the number of fools) an object of ridicule and derision. I would certainly dare to publish my reflections at once if more people like you existed; as they don't, I shall refrain from doing so." (Koestler, *The sleepwalkers,* p. 361).

The sidereal messenger. English translation of *Sidereus nuncius,* Venice 1610. Oxford, Rivington, 1880.

In this pamphlet, which caused a great sensation when it first came out in 1610, Galileo relates how he came to learn the value of the telescope for astronomical research and for the establishment of the validity of the Copernican system of astronomy. The telescope added a whole new dimension to observational astronomy.

d'autres. Sans doute m'enhardirais-je à produire au grand jour mes réflexions s'il y avait beaucoup d'hommes comme toi, mais comme il en est peu, j'aime mieux remettre à plus tard pareille entreprise."

The sidereal messenger. English translation of *Sidereus nuncius,* Venice 1610. Oxford, 1880.

Dans cette plaquette qu'il publia en 1610, Galilée décrit ses expériences avec la lunette d'approche. Il s'est tout de suite aperçu de l'utilité de cet appareil nouveau pour appuyer les théories de Copernic.

Thomas Digges (1543-1595)

Thomas Digges' diagram of the infinite Copernican universe. In Francis R. Johnson, *Astronomical thought in Renaissance England; a study of English scientific writings from 1500 to 1645.* New York, Octagon Books, 1968.

Thomas Digges was, with his teacher John Dee, one of the most eminent astronomers of Elizabethan England. He was the leader of the English supporters of Copernicus. It is in England that Copernicus' theory became linked with the idea of infinite space where the fixed stars are located "in sphaericall altitude without ende . . . "

Giordano Bruno (1548-1600)

Emile Namer, *Giordano Bruno, ou l'univers infini comme fondement de la philosophie moderne.* Paris, Seghers, 1966.

Paul-Henri Michel, *La cosmologie de Giordano Bruno.* Paris, Hermann, 1962.

Giordano Bruno, the Italian writer and philosopher, who was burned at the stake in 1600 as the result of his conflicts with the Church, outlined his ideas on the universe in many of his works. In *La cena de ceneri* (1584), he criticized Ptolemy and Aristotle and defended the heliocentric system of Copernicus. In *De l'infinito universo e mondi* (1584), he disproved the basic tenets of Aristotle's *De coelo* and put forward the thesis of an infinite universe.

Thomas Digges (1543-1595)

Thomas Digges' diagram of the infinite Copernican universe, dans Francis R. Johnson, *Astronomical thought in Renaissance England; a study of English scientific writings from 1500 to 1645.* New York, Octagon Books, 1968.

Thomas Digges et son maître John Dee sont considérés comme les astronomes les plus éminents de l'époque élisabéthaine. Digges fut le principal partisan des idées coperniciennes en Angleterre. Il fut aussi un des premiers astronomes de profession qui ait soutenu l'existence d'un monde héliocentrique et infini, où les étoiles seraient disposées "in sphaericall altitude without ende . . ."

Giordano Bruno (1548-1600)

Emile Namer, *Giordano Bruno, ou l'univers infini comme fondement de la philosophie moderne.* Paris, Seghers, 1966.

Paul-Henri Michel, *La cosmologie de Giordano Bruno.* Paris, Hermann, 1962.

Giordano Bruno, le philosophe et écrivain italien qui périt sur le bûcher à Rome en 1600, a exposé ses idées cosmologiques dans plusieurs de ses ouvrages: *La cena de ceneri* (1584), dans lequel il défend le système héliocentrique de Copernic et critique ceux d'Aristote et de Ptolémée; dans *De l'infinito universo e mondi* (1584), où il réfute les théories du *De coelo* d'Aristote et soutient la thèse de l'univers infini.

Isaac Newton (1642-1727)

Philosophiae naturalis principia mathematica . . . Amstaelodami, sumptibus Societatis, 1714.

In his great work which was first published in 1687, Newton describes his theory of universal gravitation which combined in one set of laws the motions of terrestrial and celestial bodies. Newton's law of universal gravitation, which states that "every object in the universe attracts every other object with a force inversely proportional to the square of the distance between them", broke down the Aristotelian division between terrestrial and celestial dynamics.

Edmund Halley (1656-1742)

Halley. In *Encyclopédie thématique Weber,* t. 1, p. 44-45.

Before Newton established his laws of planetary motion, the appearances of comets remained unexplained. On the basis of Newton's laws, Halley, the British astronomer, predicted that the great comet of 1682 would be seen again in 76 years. It duly appeared in January 1759, vindicating Newton's laws of planetary motion. Halley described his studies in his *Synopsis of the astronomy* of comets (1705).

Isaac Newton (1642-1727)

Philosophiae naturalis principia mathematica . . . Amstaelodami, sumptibus Societatis, 1714.

Considérée avec *De revolutionibus* comme une des oeuvres les plus marquantes dans l'histoire des sciences, cet ouvrage porte sur les trois principes de la mécanique de Newton. Il décrit la cause première, la loi initiale qui cause le mouvement des planètes et arrive à la loi de la gravitation universelle: "Deux corps quelconques s'attirent en raison directe de leurs masses, et en raison inverse du carré de la distance de leur centre de gravité". La distinction aristotélienne entre la mécanique terrestre et la mécanique céleste se trouve ainsi abolie.

Edmund Halley (1656-1742)

Halley. Dans *Encyclopédie thématique Weber,* t. 1, p. 44-45.

Avant Newton, on considérait l'apparition des comètes comme mystérieuse et inexplicable. En appliquant les lois de Newton sur les mouvements des planètes à l'orbite de la comète qui porte son nom, Halley apporta une des premières confirmations des hypothèses de son collègue. Il prédit que la comète qui avait paru en 1682 serait visible de nouveau en 76 ans. Son apparition, en janvier 1759, fut un véritable triomphe pour les théories newtoniennes. Halley résuma ses recherches dans son ouvrage *Synopsis of the astronomy of comets* (1705).

William Herschel (1738-1822)

A. Clerke, *The Herschels and modern astronomy.* London, Cassell, 1895.

Patrick Moore, *The picture history of astronomy.* New York, Grosset & Dunlap, 1972, p. 88-89.

Until the 18th century, astronomy was mainly confined to the study of the planetary system. Progress in the construction of telescopes was essential to the development of stellar astronomy. Sir William Herschel and his son Sir John F.W. Herschel (1792-1871) contributed greatly to the knowledge of the stars. In 1780, Sir William Herschel added Uranus to the planets known since antiquity.

William Herschel (1738-1822)

A. Clerke, *The Herschels and modern astronomy.* London, Cassell, 1895.

Patrick Moore, *The picture history of astronomy.* New York, Grosset & Dunlap, 1972, p. 88-89.

Jusqu'au XVIIIe siècle, l'astronomie se bornait surtout à l'étude du système planétaire. Sir William Herschel, considéré comme le fondateur de l'astronomie stellaire, observe le ciel avec un immense télescope qu'il avait construit lui-même et ajoute une nouvelle dimension à la connaissance de l'univers. En 1780, il découvre la planète Uranus.

Albert Einstein (1879-1955)

Jacques Merleau-Ponty et Bruno Morando, *Les trois étapes de la cosmologie.* Paris, Robert Laffont, 1971.

Albert Einstein (1879-1955)

Jacques Merleau-Ponty et Bruno Morando, *Les trois étapes de la cosmologie.* Paris, Robert Laffont, 1971.

"Entre 1900 et 1924 s'accomplit la seconde révolution cosmologique, dont nul ne sait encore quelle sera l'issue finale . . . D'abord, inséparablement liée à la transformation de la conception de l'univers, se produit un très profond bouleversement des fondements de la connaissance physique . . . c'est un homme presque seul, Albert Einstein, qui a d'abord franchi le pas et, rompant avec les principes apparemment les plus sûrs de la cosmologie formelle, a transformé l'idée de l'univers . . . C'est . . . la première, la théorie de la Relativité restreinte, et surtout la deuxième, la théorie de la Relativité générale qui sont décisives: l'incidence de la troisième, Mécanique quantique, et à fortiori, celle de la quatrième, la théorie des particules élémentaires, sont encore difficiles à apprécier."
(p. 184-185, 188).

Man lands on the moon

Patrick Moore, *Moon flight atlas.* New York, Rand McNally, 1970.

Recent developments in science and technology have made it possible to progress from speculation and observation to actual exploration of the planets. A feat unimaginable to the ancient astronomers: man lands on the moon and photographs the earth from 100,000 miles in space.

Patrick Moore and David A. Hardy, *The challenge of the stars.* New York, Rand McNally, 1972.

In the future lies exploration of the universe and space travel to other planets?

Le premier voyage sur la lune

Patrick Moore, *Moon flight atlas.* New York, Rand McNally, 1970.

Grâce aux progrès dans le domaine des sciences et de la technologie, on dispose maintenant des moyens de passer de la spéculation et de l'observation à l'exploration spatiale. L'homme atterrit sur la lune et contemple et photographie la terre d'une distance de 100,000 milles

Patrick Moore and David A. Hardy, *The challenge of the stars.* New York, Rand McNally, 1972.

Que nous réserve l'avenir? L'exploration de l'univers et les voyages sur d'autres planètes?

An early Canadian school-book

Nouveau traité abrégé de la sphère, d'après le système de Copernic, par demandes et par réponses. Nouvelle édition. Montréal, E.R. Fabre, 1829.

W.E. Harper, *The history of astronomy in Canada.* Toronto, Ryerson Press, 1939.

Albert D. Watson, "Astronomy in Canada", *Journal of the Royal Astronomical Society of Canada,* v. 9, 1917, p. 47-78.

"The semi-centennial of Canadian Confederation is a timely occasion for reviewing a science whose history in Canada coincides almost precisely with the life-period of the Dominion."

"Astronomy in Canada," *Journal of the Royal Astronomical Society of Canada,* v. 61, 1967, p. 211-352.

While in 1917 one article resumed the first fifty years of the activities of the Society, the centennial number devotes nine articles to the subject. The introductory article is by Dr. Kenneth O. Wright, eminent Canadian astrophysicist, who has been since 1966 the Director of the Dominion Astrophysical Observatory in Victoria, B.C. In September 1973, he was awarded the Honorary Degree of Doctor of Physical Sciences in Astronomy by the Nicholas Copernicus University at Torun.

Un manuel scolaire canadien du début du XIXe siècle

Nouveau traité abrégé de la sphère, d'après le système de Copernic, par demandes et par réponses. Nouvelle édition. Montréal, E.R. Fabre, 1829.

W.E. Harper, *The history of astronomy in Canada.* Toronto, Ryerson Press, 1939.

Albert D. Watson, "Astronomy in Canada", *Journal of the Royal Astronomical Society of Canada,* v. 9, 1917, p. 47-78.

Une vue d'ensemble du développement de l'astronomie au Canada, présentée à l'occasion du cinquantenaire de la Société royale d'astronomie du Canada.

"Astronomy in Canada", *Journal of the Royal Astronomical Society of Canada,* v. 61, 1967, p. 211-352.

En 1917, un bref article résumait les activités des premières cinquante années de la Société. Le numéro spécial du centenaire consacre neuf articles à ce sujet. L'auteur de l'introduction est le Dr Kenneth O. Wright, éminent astrophysicien canadien et directeur de l'Observatoire astrophysique de Victoria (C.-B.), depuis 1966. En septembre 1973, l'Université Nicolas Copernic de Torun conféra à M. Wright le grade de Docteur ès sciences honoris causa (Astronomie).

Some Canadian studies on Copernicus

Althéod Tremblay, "Copernic," *Le Canada français,* v. 30, mai 1943, p. 670-679.

The author, professor at Laval University, discusses the research and theories of Copernicus. The article commemorates the four hundredth anniversary of his death.

A. Vibert Douglas, "Nicolaus Copernicus," *Queens quarterly,* v. 50, Summer 1943, p. 146-154.

Dr. A. Vibert Douglas, the eminent Canadian astronomer, is also the author of a work on Arthur Stanley Eddington (1882-1944) British astronomer and exponent of the theory of relativity. Her article on Copernicus was reprinted in the *Journal* of the Royal Astronomical Society in February 1973.

W. Carl Rufus, "Copernicus, Polish astronomer, 1473-1543," *Journal of the Royal Astronomical Society of Canada,* v. 37, April 1943, p. 129-142.

Helen Sawyer Hogg, "The introduction of the Copernican system to England," *Journal of the Royal Astronomical Society of Canada,* v. 46, 1952, p. 113-117, 158-164, 195-201, 239-244; v. 47, 1953, p. 15-20.

Wanda M. Stachiewicz, *Copernicus and the changing world.* 2d rev. ed. Montreal and New York, Polish Institute of Arts and Sciences in America, 1973.

Quelques études canadiennes sur Copernic

Althéod Tremblay, "Copernic", *Le Canada français,* v. 30, mai 1943, p. 670-679.

L'auteur, professeur à l'Université Laval, décrit les théories et les recherches de Copernic. L'article parut en 1943, au moment de la célébration du quatrième centenaire de la mort de Copernic.

A. Vibert Douglas, "Nicolaus Copernicus" *Queens quarterly,* v. 50, Summer 1943, p. 146-154.

Dr A. Vibert Douglas, éminent astronome canadien, est aussi l'auteur d'une étude sur Arthur Stanley Eddington, astronome britannique (1882-1944). L'article fut repris dans le numéro de février 1973 du *Journal* de la Société royale d'astronomie du Canada.

W. Carl Rufus, "Copernicus, Polish astronomer, 1473-1543," *Journal of the Royal Astronomical Society of Canada,* v. 37, April 1943, p. 129-142.

Helen Sawyer Hogg, "The introduction of the Copernican system to England," *Journal of the Royal Astronomical Society of Canada,* v. 46, 1952, p. 113-117, 158-164, 195-201, 239-244; v. 47, 1953, p. 15-20.

Une série d'articles sur l'introduction des théories de Copernic en Angleterre.

Wanda M. Stachiewicz, *Copernicus and the changing world.* 2d rev. ed. Montreal and New York, Polish Institute of Arts and Sciences in America, 1973.

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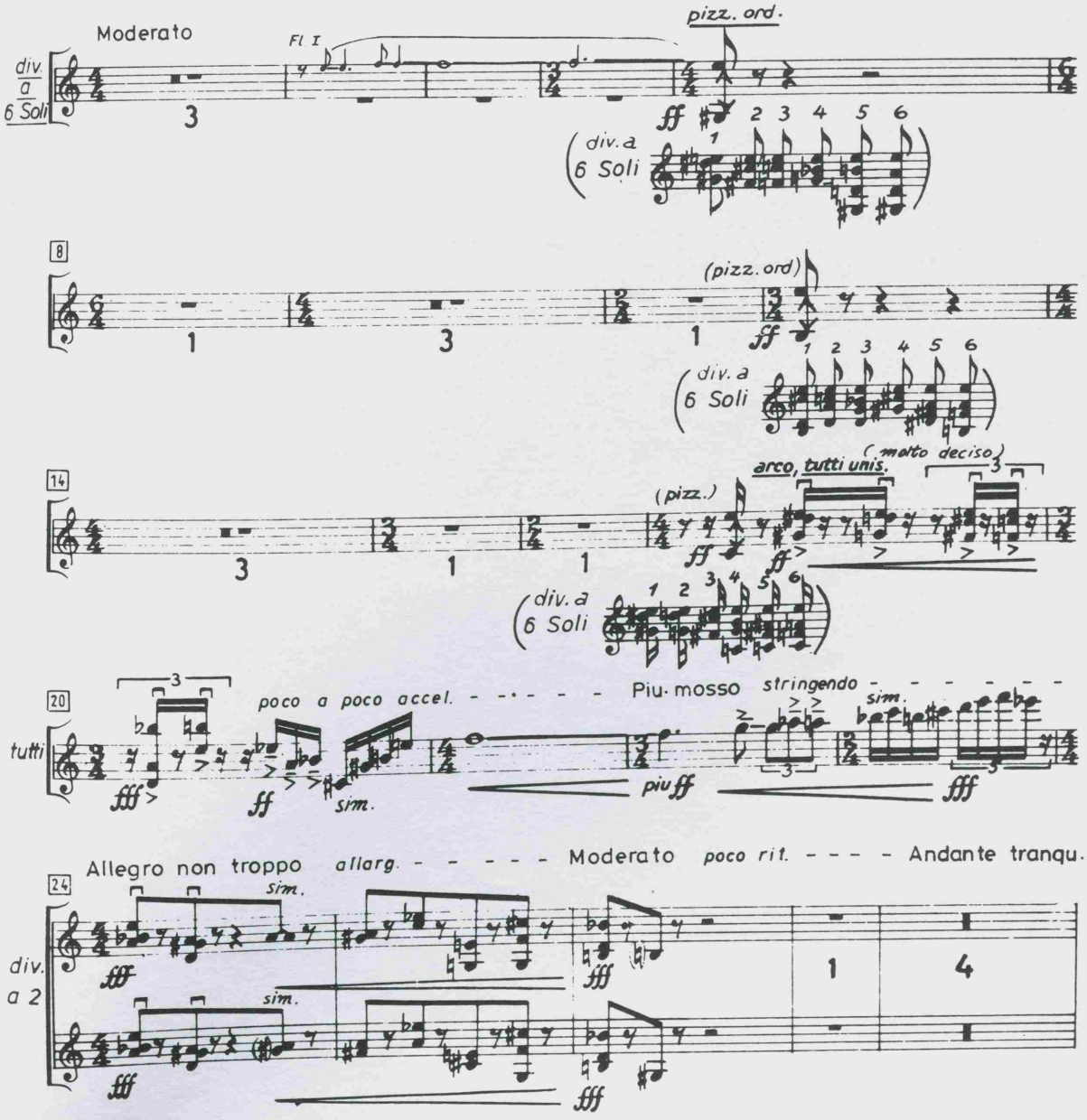
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Queen's University, Kingston
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Professor R. Klibansky, Department of Philosophy, McGill University - Copernicus and His Sources

Dr. A. Vibert Douglas, Professor Emeritus of Astronomy, Queen's University - Copernicus, The Man

Professor J. W. Abrams, Director, Institute for the History and Philosophy of Science and Technology, University of Toronto - The Epicycles of Copernicus

Professor Stillman Drake, Institute for the History and Philosophy of Science and Technology, University of Toronto - The Revolutionary Copernicans: Bruno, Kepler, Galileo

Professor D. A. MacRae, Chairman, Department of Astronomy, University of Toronto, and Director, David Dunlap Observatory - Since Copernicus: Searching for Centres

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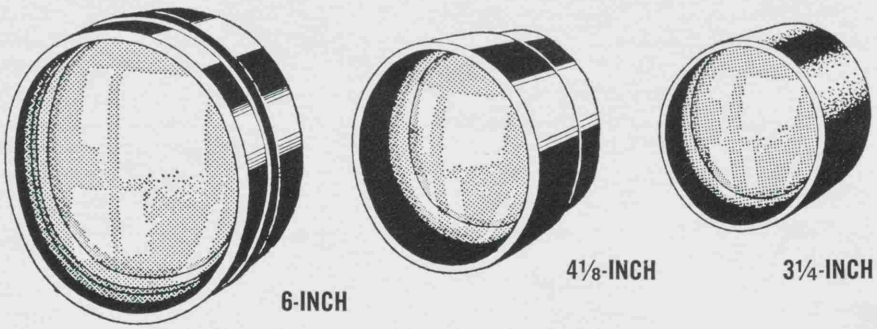

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ABOUT THE OBSERVATORY OF COPERNICUS

(Continued from page 307)

broadcast of September 14, 1970, reports as foundations that in all probability belonged to the observatory of Copernicus. These foundations "on level ground outside the Frombork town walls" are being preserved as a tourist attraction.

Thus, there is a strong case against the romantic tradition that Copernicus observed from the cathedral tower bearing his name. It is far more likely that the well-to-do canon built an observatory on his own property.

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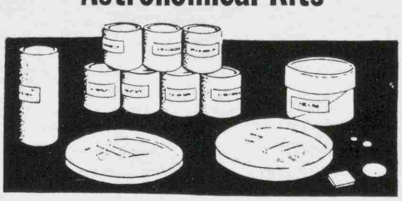

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About the Observatory of Copernicus

J. CLASSEN, *Pulsnitz Observatory, East Germany*

THERE has been some controversy as to whether or not Nicholas Copernicus (1473-1543) had an observatory. It is known that the great Polish astronomer observed in 1497 at Bologna, in 1500 at Rome, in 1518 and 1520 at Olsztyn (Allenstein), and especially in Frombork (Frauenburg). Apart from short interruptions, he lived at the last-mentioned place from 1512 to 1543. There his best observations were made. Of the 27 astronomical observations discussed in his great book, *De Revolutionibus,* nearly all are said by him to have been made at Frombork. Therefore, if indeed Copernicus had an observatory at all, it was at Frombork.

Copernicus owned instruments of considerable size. Most of his measurements were made with a quadrant, a triquetum, and an armillary sphere. According to Ernst Zinner, a modern German historian of astronomy, the square plate of the quadrant was 1.7 meters ($5\frac{1}{2}$ feet) on a side. The triquetum had a sighting arm 1.9 meters ($6\frac{1}{4}$ feet) long and hung from a pillar at least $2\frac{1}{2}$ meters (eight feet) tall. The armillary seems to have had an ecliptic ring some 57 centimeters (22 inches) in diameter, and a meridian ring a quarter again as large. Where were all these sizable instruments lodged when observing was in progress?

As a canon of the Frombork cathedral, Copernicus lived outside the town wall in a house having a small farm and garden. He worked in this dwelling when his duties did not call him to the cathedral, and it was here that Copernicus died, according to E. Brachvogel. Moreover, like most of the other canons, he had a tower inside the fortified cathedral, intended as a place of refuge in time of war. The tower assigned to him, which as early as 1610 was called "the Copernicus tower," formed the northwest corner of the cathedral. With a floor area of 8 x 9 meters (26 x 30 feet) and 16.5 meters (54 feet) tall, it has been a museum and historical monument since 1912.

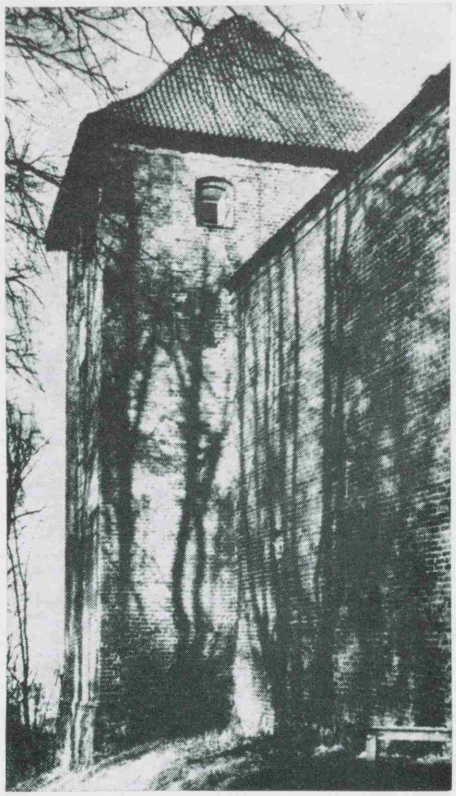
Tradition states that the observatory of the great astronomer was in the upper chamber of the Copernicus tower. Also, it is said that there used to be a balcony on which the instruments were set up. All biographies of Copernicus accept this tradition as factual. In Frombork the story is still told today.

But, as the writer recently pointed out, the geometry of the tower contradicts this tradition. The windows of the Copernicus tower are only 70 centimeters (28 inches) wide – quite inadequate for observing with large instruments. There is no sign of any supports for the balcony upon the walls of the tower, whose summit is only one meter (three feet) across. In particular, the journey from Copernicus' dwelling to the upper room of this tower must have been long and difficult. Every practical astronomer prefers a conveniently accessible site for nighttime observing.

It would have been convenient for Copernicus to have observed at his dwelling, where he had a garden and could have erected a small structure more easily than on cathedral property.

In 1967 J. Pagaczewski of Krakow Observatory came to the conclusion that Copernicus had two observing sites in Frombork: one in the so-called Octagon, the other near the house of Ecard (or Eggerta) von Kempen. But why two observing places?

My recent critical analysis of the source materials has been based primarily upon E. Brachvogel's study of the tradition regarding the observatory of Copernicus, and upon Tycho Brahe's account of a visit to Frombork by his student Elian Olsen Cimber. My conclusion is that Copernicus observed only in the vicinity of his dwelling, and that he had a fixed observatory there. This result has also been reached by the Polish historian of astronomy, E. Rybka.

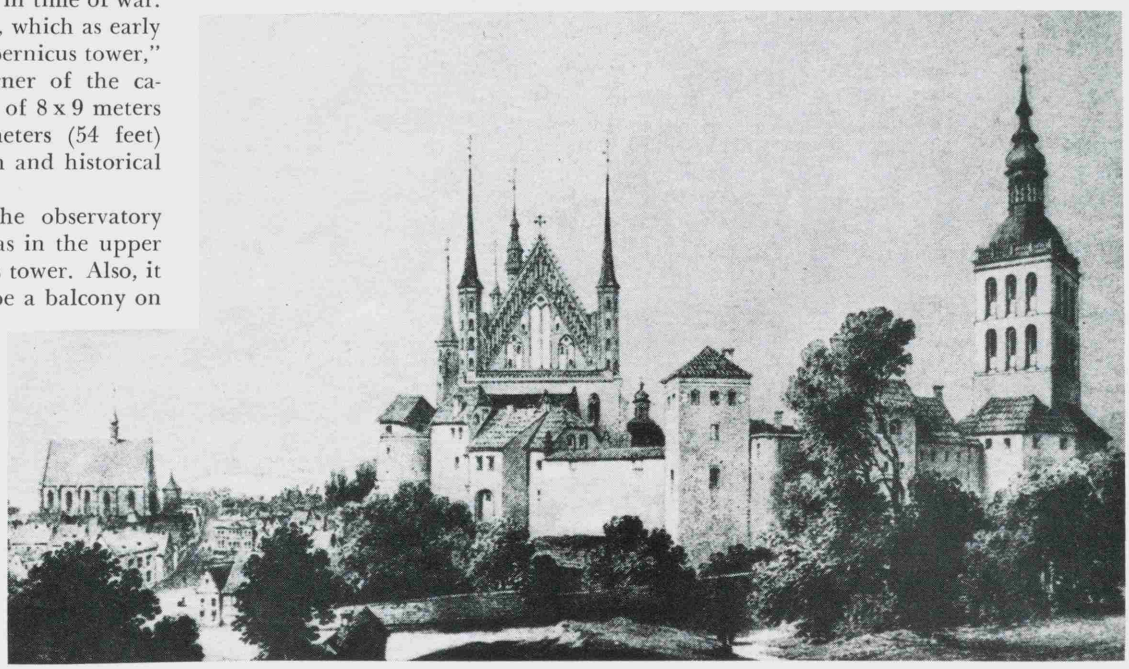


The so-called Copernicus tower in the Polish town of Frombork is the traditional site of his observatory. From the book *Mikolaj Kopernik,* Warsaw, 1953, Plate 27.

Copernicus' house was neither the building later occupied by von Kempen nor a building adjoining it. Only during wartime, as in 1520, would the astronomer's dwelling have been unsuitable as an observing place.

The location of von Kempen's home was for a long time unknown, and as recently as 1943 Zinner thought that it was beyond discovery. However, Polish investigators have identified it. Near that place have been found what a Polish radio

(Continued on page 312) over →



Frombork in 1840 is seen from the west in this engraving by F. von Quast (1807-77). In the middle is the cathedral, while the square Copernicus tower is slightly to its right.

Copernicus and Tycho

Owen Gingerich

Scientific American Dec. 1973

COPERNICUS AND TYCHO

In which the author, exploring who read Copernicus' book at the time of its appearance, discovers Tycho's personal copy of it. Tycho's notes show how he evolved his non-Copernican model of the solar system

by Owen Gingerich

In the flamboyant frontispiece to G. B. Riccioli's *Almagestum novum* (*New Almagest*), published in 1651, Urania, the goddess of the heavens, holds a balance that is weighing the Copernican world system against the Tychonic system [*see illustration on opposite page*]. In the Copernican system all the planets revolve around the sun. In the geocentric Tychonic system, which Tycho Brahe proposed several decades after Nicolaus Copernicus had advanced his heliocentric model, the sun travels around the fixed earth, carrying the rest of the planets with it. For Riccioli the geocentric system put forward by Tycho carried the most weight. Today we view Tycho's scheme as a giant step backward, but we are nonetheless disconcerted by the fact that it was proposed by the most innovative astronomical observer since antiquity. Tycho's bold plan for increasing the accuracy of observations places him far more securely in the mainstream of modern astronomy than Copernicus himself.

Just this past May I made a discovery that now puts Tycho's view in a more favorable light. Bound into an edition of Copernicus' *De revolutionibus orbium coelestium* in the Vatican Library I found the original working copy of Tycho's cosmological notes. It is perhaps unnecessary to add that this came as a great surprise. These hitherto unknown personal notes record the germination of Tycho's conception and contain the first sketches of his planetary system.

To appreciate the full significance of the notes it is necessary to look afresh at the context of Copernican astronomy in the 16th century. When Copernicus introduced his heliocentric arrangement, the earth became one of the family of planets revolving in off-centered circles around the sun. Copernicus sought a system that was "pleasing to the mind," and he was particularly delighted with his proposal because the planets naturally ranked in order from the sun according to their speeds, with the slowest one revolving in the largest orbit. (At the time the slowest planet known was Saturn.)

In contrast, Tycho's planetary system, in which the earth regained its privileged central status, at first seems clumsily contrived. More important in the context of astronomy a century before Newton, however, is that the immobile earth of the Tychonic system fitted the accepted laws of physics where the moving-earth Copernican model did not. Tycho complained that Copernicus' system "ascribes to the earth, that hulking, lazy body, unfit for motion, a motion as quick as that of the ethereal torches, and a triple motion at that." Nevertheless, to most of Tycho's contemporaries this complaint hardly mattered; the majority of 16th-century astronomers considered astronomical systems as being elaborate geometric hypotheses quite removed from physics. The gradual acceptance of a celestial physics integrated with terrestrial physics, culminating in the synthesis by Newton, is undoubtedly the most significant scientific aspect of the Copernican revolution.

The ultimate goal of a planetary model is to predict the planets' positions. In this respect the geocentric epicyclic system proposed by Ptolemy around A.D. 140 succeeded admirably. In order to be taken seriously any alternative proposals had to do as well. Copernicus realized that; thus only a few pages of *De revolutionibus* directly concern the heliocentric cosmology. The bulk of it is devoted to technical details leading to tables describing the motions of the planets. In the 16th century Copernicus was regarded as a master mathematician not for his innovative cosmology but for his ability to cope with the details of predicting the positions of the planets.

Actually the tables of *De revolutionibus* offered little improvement over those of Ptolemy. That is not surprising considering the lack of a suitable base of observations from which to compute the tables. Copernicus was forced to rely heavily on the same observations Ptolemy had recorded. Not until Tycho initiated his vast program of systematic observations in the 1570's did anyone fully realize how faulty the tables were, or whether Copernicus had offered any improvement.

Although the astronomers of Copernicus' day had only rather primitive instruments, it was possible to make certain observations quite accurately without any instruments at all. Copernicus' earliest recorded observation, in 1497,

FRONTISPIECE TO "ALMAGESTUM NOVUM" (*New Almagest*) by G. B. Riccioli, published in 1651, shows the earth as the bearded man at the left covered with eyes, holding a telescope and gazing up at the newly discovered marvels of the heavens: the odd shape of Saturn (due to its rings) in the top right corner, Jupiter with its four bright satellites just below, the rough appearance of the moon's surface and a comet. In the top left corner the cherubim, from top to bottom, are holding Mars, Venus, the sun and Mercury. To earth's right is the star-covered goddess of the heavens, Urania, holding an armillary sphere in her left hand and a balance in her right. The balance is testing the Copernican heliocentric system of the universe against the geocentric system of Tycho Brahe. For Riccioli the Tychonic system carried more weight. Ptolemaic system is discarded at Urania's feet; Ptolemy himself is watching over proceedings and commenting: "I erred so that I could be corrected."

t. d' quo dicit Egidius q' ille
regimen dedit cum p duobus
bulas astronicas correctis
ooo

lmo gylicto

ooo
o fuit scda fuit o ☽ ♑ m 15 42 d
☌ bononie
a nocte fuit o ☽ ♑ in 18 20 d
dine visa ♋ et alia visa * per
☌ bononie

tract written about 1512 and circulated only as a manuscript, he wrote concerning the planetary motions that "eventually it came to me how this very difficult problem could be solved with fewer and much simpler instructions than were formerly used, if some assumptions were granted me." Copernicus went on to outline his new heliocentric arrangement of the planets, indicating that the apparent celestial motions could be explained by a triple movement of the earth itself: the revolution on its own axis, the orbital motion around the sun and the libration, or wobble, of its axis that accounts for the precession of the equinoxes.

In addition to putting forward the heliocentric concept, Copernicus awarded virtually the same weight to a second philosophical principle: the Platonic-Pythagorean concept that celestial movements must be composed of uniform circular motions. That principle constituted a strong criticism of one of the chief Ptolemaic devices: the equant. In order to understand the equant and the force of this argument against it, one must first notice the chief features of Ptolemy's planetary mechanism. The earth was placed near, but not exactly at, the center of a set of the large deferent circles. Each planet moved with uniform circular motion on an epicycle that was on the deferent. The epicycle produced the planet's periodic retrograde motion among the stars, in which the planet appeared to stop temporarily and then "back up" westward in the sky before stopping again and resuming its usual easterly path. In the Copernican system the epicycle is seen as the result of the earth's own orbital motion around the sun: the retrogression of a superior planet is caused by the faster-moving earth passing that planet. In the case of Mars the irregularity generated by the epicycle to account for retrograde motion could modify the position of the planet by as much as 45 degrees of arc compared with the effect of uniform circular motion on the deferent alone.

In addition to the irregularity of the planet's motion produced by the epicycle, a nonuniform motion of the center of the epicycle on the deferent was also required. To achieve this nonuniform motion Ptolemy devised the equant: an axis of uniform motion off center within the deferent. Only from that position would the planet appear to move with uniform circular motion. In addition the earth was placed equally off center in the opposite direction. In the case of Mars the equant and the off-center displacement could modify the uniform motion by a substantial amount, up to 12 degrees of arc to the east or west. The use of the equant, the epicycle and the eccentric deferent gave Ptolemy adequate flexibility for coping with the superior planets and with Venus; with the addition of one small central circle he was able to manage Mercury as well.

Copernicus opened his *Commentariolus* with an attack on the Ptolemaic equant, which appeared to violate the principle of uniform circular motion. "A system of this sort seems neither sufficiently absolute nor sufficiently pleasing to the mind," he wrote. "Having become aware of these defects, I often considered whether there could perhaps be found a more reasonable arrangement of circles from which every apparent inequality would be derived and *in which everything would move uniformly about its proper center, as the rule of absolute motion requires.*" A major theme of Copernicus' work thus became the geometric elimination of the equant. Copernicus turned to an epicyclet, or small epicycle, to effect the substitution. The result was that, although he simplified the planetary system by removing the large epicycles, his devotion to the principle of uniform circular motion caused him to introduce new complexities.

At the end of his *Commentariolus* Copernicus remarked: "All together, therefore, thirty-four circles suffice to explain the entire structure of the universe and the entire ballet of the planets." Commentators in the 19th century used their imagination to embellish Copernicus' statement and, without checking the facts, began to propagate the story that Ptolemy's rather simple system had become overlaid with dozens of additional secondary circles by the time of Copernicus.

Alfonso X may have contributed to the legend at the end of the 13th century; he is reputed to have told his astronomers that if he had been present at the Creation, he could have given the Lord some hints. This anecdote has fed the mythology, so that a recent *Encyclopaedia Britannica* article even asserts that 40 to 60 epicycles were required for each planet! Actually even at the time of Copernicus observational astronomy was still in such a primitive state that there could have been no observational basis for such a cumbersome improvement.

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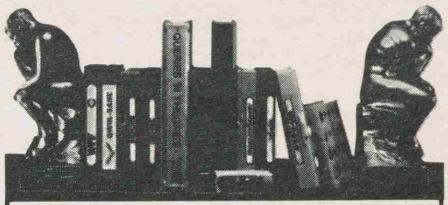

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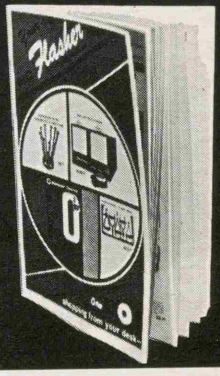

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ever used for actual planetary tables. Whether Copernicus conceived of the double-epicyclet replacement of the equant independently or whether he inherited it from the Arabs by some as yet unknown channel remains moot

During the 1520's Copernicus worked extensively to elaborate his ideas, particularly the planetary theory, if we are to judge by the sprinkling of planetary observations recorded in *De revolutionibus*. By this time he was well settled in northern Poland, but a variety of administrative duties frequently kept him away from his celestial researches. During that time Copernicus wrestled with the writing of a monumental treatise comparable in scope to Ptolemy's *Almagest*. It was to incorporate the twin principles that the sun is at the center of the solar system and that the planetary movements are based on uniform circular motion. The heavenly movements turned out to be more complicated than he had supposed in the *Commentariolus*. In particular the lines of apsides, or the lines between the earth and the equants in the Ptolemaic system, appeared to turn slowly with respect to the stars. Only a few observations, some of them contradictory, had come down through history, and Copernicus must have toiled with some frustration trying to satisfy them all. He eventually abandoned the double epicyclets of the *Commentariolus* in favor of an off-center deferent and a single epicyclet, a scheme that more readily accommodated the shifting apsides. For Mercury, however, he retained the double epicyclet to replace not the equant but the additional central circle postulated uniquely for that planet by Ptolemy. In the end Copernicus managed to pile up more small circles than Ptolemy.

The major part of *De revolutionibus* is devoted to a detailed analysis of the motions of the sun, the moon and the planets using combinations of large circles and small circles. This analysis, together with a mathematical commentary and tables of stars, constitutes 96 percent of the volume. Scarcely 20 pages of *De revolutionibus* are devoted to the new heliocentric cosmology. The opening chapters review the ancient arguments for a geocentric world view along with quaintly medieval counterarguments. They give little hint of what is about to come in the chapter titled "On the Order of the Celestial Orbits." That chapter is a resounding defense of the heliocentric system based entirely on aesthetics, particularly on the principle of simplicity In a powerful plea for the heliocentric world view Copernicus wrote: "At rest in the middle of everything is the sun. For in this most beautiful temple, who would place this lamp in another or better position than that from which it can light up the whole thing at the same time? Thus indeed as though seated on a royal throne, the sun governs the family of planets revolving around it."

The sun-centered system offered an elegant explanation for retrograde motion, including puzzling details that had no rationale in the Ptolemaic scheme. Furthermore, with the heliocentric arrangement of the planets the spacings between them are no longer arbitrary but are fully specified by the configuration. This is surely one of the most persuasive aesthetic considerations in favor of the Copernican cosmology. There is a whiff of reality here, particularly in Copernicus' resounding conclusion: "So vast without any question is this divine handiwork of the Almighty Creator." Yet very few people in the 16th century grasped the harmonious, aesthetic unity Copernicus saw in the cosmos.

Any thought that Copernicus was talking about a real system must have rapidly vanished from the minds of those few astronomers who managed to plod their way through the remainder of the treatise. Copernicus' application of the second aesthetic principle, uniform circular motion, was far from unambiguous. Like Ptolemy, he occasionally paused to mention alternative geometric arrangements. The crushing blow to any physical reality for the planetary epicyclets, if any were needed, comes in Book Six, where Copernicus was obliged to adopt details for predicting the latitudes of the planetary positions different from those he had used for predicting their longitudes. Although few readers ever managed to get that far, the hypothetical nature of the constructions was stated at the very beginning of the book—not by Copernicus but by an anonymous editor in the printshop. Most major astronomers of the ensuing decades found out that its author was a Lutheran theologian, Andreas Osiander, who probably preferred not to sign a statement in a book written by a Catholic and dedicated to the Pope. Osiander's introduction stated that the author, following his duty as an astronomer, had devised hypotheses so that the planetary positions could be calculated for any time. "But these hypotheses need not be true or even probable," he wrote. "If they provide a calculus consistent with the observations, that alone is sufficient."

The careful reader of *De revolutionibus* interested merely in the technical details of planetary motion might have been greatly inspired by Copernicus' adherence to the principle of uniform circular motion; he surely would have agreed with Osiander's analysis. On the other hand, a reader with a speculative turn of mind, seizing the aesthetics of the heliocentric principle, might have found himself in violent disagreement with Osiander.

Did the book actually have any careful readers? That question arose in a conversation I had three years ago with another student of Copernicus, Jerome Ravetz [see "The Origins of the Copernican Revolution," by Jerome R. Ravetz; SCIENTIFIC AMERICAN, October, 1966]. In our discussion we speculated that there are probably more people alive today who have read *De revolutionibus* carefully than there were in the entire 16th century. We counted on the fingers of two hands the candidates for that early era: (1) Georg Rheticus, the Wittenberg scholar who came to Poland and who persuaded Copernicus to publish his book; (2) Erasmus Reinhold, the Wittenberg professor who stayed home and who later composed the Prutenic Tables based on Copernicus' work; (3) Johannes Schöner, the Nuremberg scholar who was closely associated with the printshop and who was the man to whom Rheticus addressed his first published report on the Copernican system; (4) Tycho Brahe; (5) Christopher Clavius, the Jesuit who engineered the reform of the Gregorian calendar; (6) Michael Maestlin, Kepler's astronomy teacher, and (7) Johannes Kepler himself.

At the time I was on a sabbatical leave from the Smithsonian Astrophysical Observatory. Two days after talking with Ravetz I happened to visit the remarkable Crawford Collection of rare astronomical books at the Royal Observatory in Edinburgh. There I admired one of the prize possessions, a copy of the first edition of *De revolutionibus*, handsomely annotated in legible inks of several colors. As I examined the book I realized that the intelligent and thorough notations were undoubtedly made before 1551, that is, within eight years after the publication date of 1543. My speculation with Ravetz from two days earlier seemed to be knocked into a cocked hat, because it hardly seemed likely that, if intelligent readers of *De revolutionibus* were so rare, the very next copy of the book that I saw would be so well annotated.

Then a second thought crossed my mind: Perhaps the Crawford copy had

venient Prutenic Tables for carrying out the Copernican planetary calculations, he is frequently listed as an early adherent of the heliocentric cosmology. The nature of the tables, however, makes them quite independent of any particular cosmological system. Moreover, although his introduction is full of praise for Copernicus, nowhere does he mention the heliocentric cosmology. With his great interest in alternative mechanisms, there is reason to suspect that Reinhold was on the verge of independently discovering the Tychonic system, but he died of the plague at an early age before he could consolidate any cosmological speculations of his own.

Flushed with the success of identifying Reinhold's copy, I resolved to examine as many other copies of the book as possible in order to establish patterns of readership and ownership, always hoping to find further interesting annotations. For three years I systematically sought out copies in such far-flung places as Budapest and Boston, Leningrad and Louisville, Copenhagen and San Juan Capistrano. In the process I saw and photographed copies annotated by Kepler (in Leipzig), by Maestlin (in Schaffhausen, Switzerland), by Tycho (a second edition, in Prague) and by Rheticus (a presentation copy in Connecticut). I also found copies annotated by astronomers we forgot to put on the original list: the ephemeris-maker Johannes Stadius (at the United States Military Academy at West Point) and by Casper Peucer, Reinhold's successor as astronomy professor at Wittenberg (at the Paris Observatory). In all, I had managed to see 101 copies of *De revolutionibus* by this past spring. The investigation confirmed that the book had rather few perceptive readers, at least among those who read with pen in hand. In spite of that, however, the book seemed to have a fairly wide circle of casual readers, much larger than has been generally supposed.

In May I had the opportunity to visit Rome, where there were seven copies of the first edition that I had not examined. My quest took me first to the Vatican Library, where I went armed with shelfmark numbers provided by my Polish colleague Dobrzycki. Some of the books in the Vatican Library had come there with the eccentric Queen Christina of Sweden, who had abdicated her throne in 1654, abandoning her Protestant kingdom for Rome. Her father, Gustavus Adolphus, had ransacked northern Europe during the Thirty Years' War and among other things had captured most of Copernicus' personal library Dobrzycki had gone to Rome in search of Copernican materials that Queen Christina might have taken along. In the Vatican he found an unlisted copy of Copernicus' book among the manuscripts. Because the book was published just when Copernicus died Dobrzycki knew that it could not have belonged to Copernicus himself, and so he proceeded on to other materials. Fortunately for me, he gave me the number for the volume, which could not have been found in the regular Vatican card catalogues.

When I examined this copy, I realized that the extensive annotations in the margins must have been made by a highly skilled astronomer. At the end were 30 most interesting manuscript pages bound into the volume, full of diagrams made by someone working along the same lines as Tycho and dated 1578. Although there was no name anywhere on the volume, I conjectured that the annotations might have been made by the Jesuit astronomer Christopher Clavius, because his copy of *De revolutionibus* was one I had not yet found. In a state of considerable excitement I got in touch with D. J. K. O'Connell, the former director of the Vatican Observatory. With his help I obtained Xerox copies of two letters by Clavius from the Jesuit Archives. Eagerly I returned to the Vatican Library, only to have my hypothesis smashed within minutes. There was no possibility that the writing in the *De revolutionibus* was the hand of Christopher Clavius.

I left Rome in a baffled and troubled state for a conference on Copernicus in Paris. There, by a fantastic stroke of luck, I received the new facsimile of the second edition of *De revolutionibus* that is preserved in Prague, and which contains annotations by Tycho. I think my heart must have stopped for a moment when I saw the handwriting in the facsimile: I then realized that the first edition in Rome was probably also in Tycho's hand. What I had found in the Vatican Library was Tycho's original working copy, probably the most important Tycho manuscript in existence. The second edition in Prague was a derivative copy; it had been annotated by Tycho with the thought that it might possibly be published.

I rebooked my flights and went back to Rome. After I had put the Prague facsimile side by side with the Vatican copy, it took only a few minutes to prove this conjecture. Afterward the Vatican librarians traced the book to Queen Christina, who must have gained possession of it in 1648 when her troops captured the collections formed by Rudolph II in Prague.

On the title page of Tycho's copy in the Vatican appears the very same words that Reinhold had inscribed on his copy: "The axiom of astronomy: celestial motions are uniform and circular, or composed of uniform and circular parts." I had already known that in 1575, three years before the dated annotations in this book, Tycho had visited Reinhold's son in Saalfeld and had seen Reinhold's manuscripts. Knowing this, I had guessed that Tycho's own cosmological views grew from seeds planted at Wittenberg by a tradition that honored Copernicus but followed Osiander's admonition that it is the duty of the astronomer to "conceive and devise hypotheses, since he cannot in any way attain the true causes." The newly found Tycho copy dramatically confirmed this intellectual heritage, not only through the motto on the title page but also within the book itself, where numerous annotations are copied word for word from Reinhold. In particular Tycho, like Reinhold, specifically numbered any alternative arrangements of circles indicated by Copernicus. Like Reinhold, he must have viewed Copernicus as a builder of hypothetical geometric models.

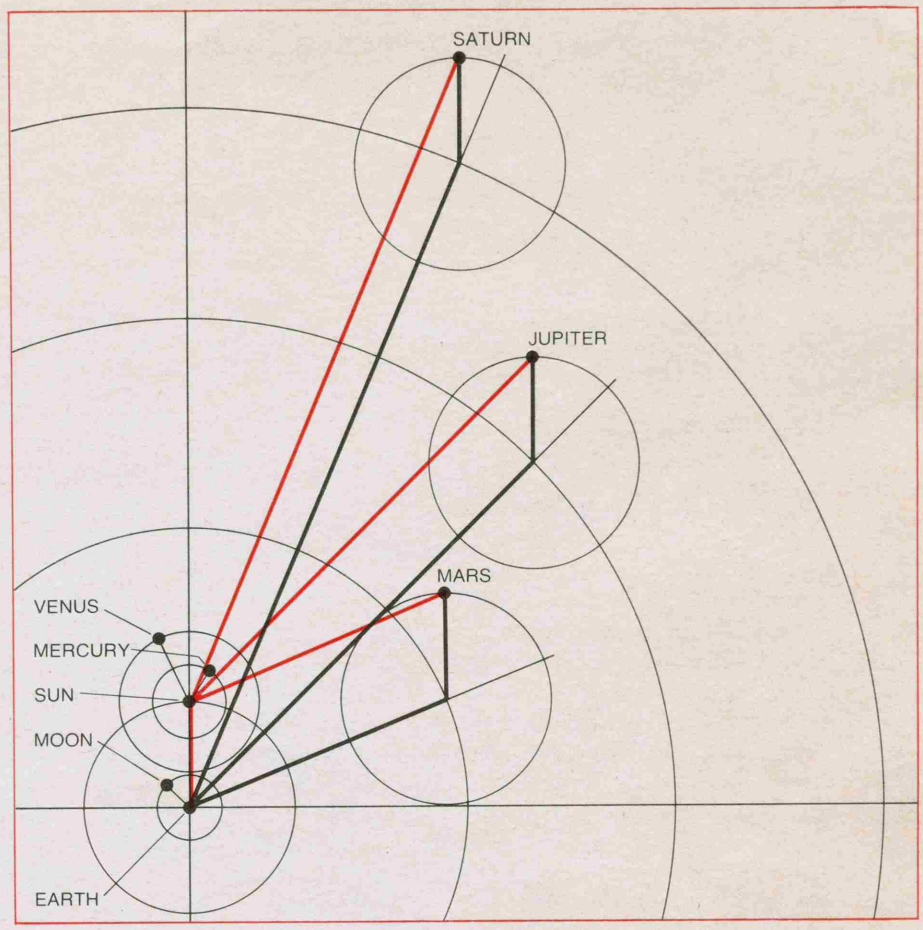
The most exciting aspect of the Vatican volume is the sequence of 30 manuscript pages at the end. Apparently they are very preliminary working notes on Tycho's own geocentric system. The first opening is dated January 27, 1578, the day after the spectacular comet of 1577 had been seen for the last time. The diagrams on those two pages are heliocentric, and a note in the corner indicates that it was drawn according to the third hypothesis of Copernicus, corresponding to one of Tycho's enumerations marked in the margin of the printed book.

Diagrams drawn about three weeks later show a geocentric arrangement for the first time, and Tycho noted that "this new hypothesis occurred to me in the year [15]78 on the 13th day of February" [*see illustration on page 90*]. Seldom can we pinpoint the moment of a centuries-old discovery so precisely! In a series of charts Tycho explored alternative positions of the single epicyclet for Venus and the pair of epicyclets for Mercury.

Two days later, on the very next page, Tycho drew the most interesting diagram of the entire sequence [*see illustration on next page*] It is easy to recognize as a proto-Tychonic system: the earth is at the center, circled by the moon and the sun. Tycho placed the orbits of Mer-

the heliocentric teachings of the master.

It is curious that Tycho did not publish his new system until a decade later. Tycho was a dynamic young man of 31 when he wrote this manuscript and already well established on the island of Hven, but perhaps still uncertain where his observations for the reform of astronomy would lead him. A passage in his *De mundi aetherei recentioribus phaenomenis* implies that he did not establish the Tychonic system until around 1583, five years after he drew these diagrams. I can only suppose that those five years were an important time of maturing. In that interval Tycho must have speculated on the movement of the great comet of 1577, realizing that it would have smashed the crystalline spheres of the ancient astronomy, had they existed, as it moved through the sky. Perhaps he began to look for greater certainty in astronomy and to suppose that the observations made with the giant instruments at his Uraniborg observatory could lead beyond hypothesis to physical reality. If so, like his contemporaries in that pre-Newtonian, predynamical age, he must have viewed the physics of the sluggish, heavy earth as a most important phenomenon to be preserved. We can well imagine that Tycho believed he was taking a great step forward toward understanding the physical reality of the universe when he adopted his own geocentric system.



TYCHONIC SYSTEM can easily be obtained from Tycho's final diagram (*see illustration on opposite page*). Vertical line from center of each epicycle to its planet is the same length as the distance between the earth and the sun since the size of the epicycles and of the sun's orbit is the same. All that remains to finish construction of Tychonic system is to complete the parallelogram by drawing a line from sun to each superior planet (*color*).

Curiously enough, Tycho's system retained many of the advantages offered by Copernicus: the planetary orbits were linked together in a coherent unit, and retrograde motions were "naturally" explained. Although his scheme conceded little to the special properties of the sun among the planets, it carefully preserved the time-honored uniqueness of the central earth. Yet there was one aspect, absolutely crucial for the further development of physics, lacking in the Tychonic arrangement. In the Copernican system the planets are harmoniously ordered out from the sun so that the shorter the period, the closer the distance. It is this pattern that opened the way to the mathematization and mechanization of the universe.

In retrospect the Tychonic system, which weighs so heavily in Urania's balance, looks clumsy and wrong—a monumental step backward. Thus Tycho is today rejected as a cosmographer and he is lauded as the ingenious instrument builder whose systematic observations provided the foundations for Kepler's laws. Kepler in turn is hailed as the number-juggler whose elliptical orbits finally vanquished the ancient requirement of uniform circular components for celestial motions.

Weighed against the Tychonic scheme, the heliocentric system appears neat and orderly to us living after the time of Newton. Indeed, it is precisely this elegant organization that Copernicus found pleasing to the mind, and which led to his cosmology. Early in *De revolutionibus* he wrote: "In this arrangement, therefore, we discover a marvelous symmetry of the universe, and an established harmonious linkage between the motion of the spheres and their size, such as can be found in no other way."

It was precisely in this arrangement that Kepler saw the real possibility of a celestial physics, and he took the first groping steps toward a dynamics of the heavens—dynamics that, when they were reshaped and powerfully formulated by Newton, ultimately proved to be the primary justification for the heliocentric universe. It may well be that Kepler's vision of a cosmic physics shaped the development of science far more significantly than the discovery of his three laws of planetary motion. And quite possibly Tycho's own insistence on a physically acceptable and not merely hypothetical astronomy influenced the young Kepler's views on the nature of the universe. It was in this tradition that both Kepler and Galileo taught us to use our senses to distinguish between the various hypothetical world views, allowing only the ones that were consistent with the observations.

Only in our own generation have we been able to break the terrestrial bonds; men flung out toward the moon have seen the spinning earth, a blue planet, sailing through space. Copernicus' daring concept has been vindicated. Seen by him only in the mind's eye, the concept of the moving earth became the essential first step toward a physics that embraced both the earth and the sky. Thus in reality the Copernican quinquecentennial celebrates the origins of modern science and our contemporary understanding of the universe. Fittingly we honor not only the renowned Polish astronomer but also his illustrious successors—Kepler, Galileo, Newton, and, in a new light, Tycho Brahe.