Part II

HISTORY OF SCIENCE IN GDAŃSK

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16. The Gdańsk Coryphaei of Science

The pre-partition Gdańsk was the largest Baltic port, as well as the lar-gest and richest city in the Polish Republic [Fig. 15]. The source of wealth were the abilities and industriousness of the inhabitants who knew how to use the pri-vileges granted to them by Polish kings, ensuring them a monopoly in the ma-ritime trade. In practice, up to 80% of all domestic exports and imports went

Figure 14. The Main Building with the turret reconstructed in 2013 (Photo: Januszajtis A.)

through Gdańsk, and the resources of the city treasury were sometimes comparable to the budget of the Polish Republic. A measure of the prosperity may be the outcome of the property census conducted by the Prussians in 1793, after the seizure of Gdańsk – which was already greatly impoverished at that time: it was noted that the city was inhabited by 200 wealthy people owning the property worth millions of thalers and 1700 who had over 100,000. After conversion to the money of today, this means that every twentieth inhabitant of Gdańsk was a millionaire! However, more important than money were the aims for which it was expedited. The largest part of the budget was spent on the defence and the municipal and port infrastructure, nonetheless, a significant amount was also allocated to education, science and culture. The city authorities took care of the development of education. In addition to the Gymnasium founded in 1558, which was academic in nature from 1580 (seven departments), there were six parish schools and several dozen private institutions. In 1596, the Gdańsk Library, still existing today, was opened. It never happened that the Council would refuse someone a scholarship to study abroad. Private contributions of rich burghers were also significant. No wonder then that many outstanding scientific and technical achievements were achieved in Gdańsk. The scientists from Gdańsk gained international recognition. Achievements recognized on a worldwide scale will be discussed here.

The late 18^{th} century was adopted as the upper time limit, with occasional additions up to 1945. The titles of the works and dissertations are given in the English translations.

17. Joachim Rheticus

The importance of the Gdańsk centre for the world science is evidenced by the fact that it is here that *Narratio Prima* presenting the knowledge about the heliocentric system of Nicolaus Copernicus was published for the first time in the world. Its author was the outstanding Austrian mathematician and astronomer Georg Joachim Rheticus. Born in 1514 in Feldkirch, son of physician Georg Iserin, and Tomassina de Porris of Italy, he was educated by his father until the age of 14. After the death of his father, who was executed for alleged sorcery, he took his mother's surname - von Lauchen in the German version, however, he would more often use the toponym Rheticus for his home region where he was born (Rheticus - from Rhaetia). Having graduated from the school at the New Collegiate Church (Neumünsterschule) in Zurich, he began to study mathematics at the University of Wittenberg in 1533.

Figure 15. Gdańsk around 1680 (Stech A., the original in the Museum of the City of Gdańsk)

In 1537, with the support of Philip Melanchthon, he became professor of mathematics and astronomy there. From 1538 he travels, first to Nuremberg, where he meets the publisher Johann Schöner and the printer Johann Petreius. Later he visits Ingoldstadt, Tübingen and his native Feldkirch. In May 1539, he arrives at Frombork to visit Nicolaus Copernicus and gives him as a gift five books, including three published by Petreius:

1. *Almagest* by Ptolemy, Basel 1538 (vol. I);

2. *Opticae* by Witelo, Nuremberg 1535 (vol. II);
3. *Instrumentum primi mobilis* by Apianus, Nuremberg 1534 (vol. II);
4. The Greek edition of *Geometry* by Euclid, Basel 1533 (vol. III);
5. *De triangulis Regiomontana*, Nuremberg 1533 (vol. III).

They spend the summer together in Lubawa with the scholar, bishop Tiedemann Giese of Gdańsk. Rheticus and Giese urge Copernicus to publish his work, and the *First Account* before that. In September Rheticus travels to Gdańsk, where he meets the mayor (Bartholomäus Brandt or Johann von Werden) and obtains financial assistance to publish the account. While waiting for the account to be printed, he measures the magnetic declination - one of the first in history (previously, in 1536, it was measured in Nuremberg and Rome only). Owing to him and his successors, in Gdańsk we have a record of the world oldest curve showing its changes.

The book is published in the spring of 1540 at Franciszek Rhode's printing shop in Gdańsk which had been established two years before [Fig. 16]. Its title takes the form of a letter: "To the Illustrious Master, Johannes Schöner about the Books on the Revolutions by the Most Learned Man, the Most Magnificent Mathematician, the Venerable Doctor, Nicolaus Copernicus, the Canon of Ermland, the First Account by a young man involved with mathematics." Its contents are a comprehensible description of the heliocentric system and the arguments to support it. We read there, *inter alia*:

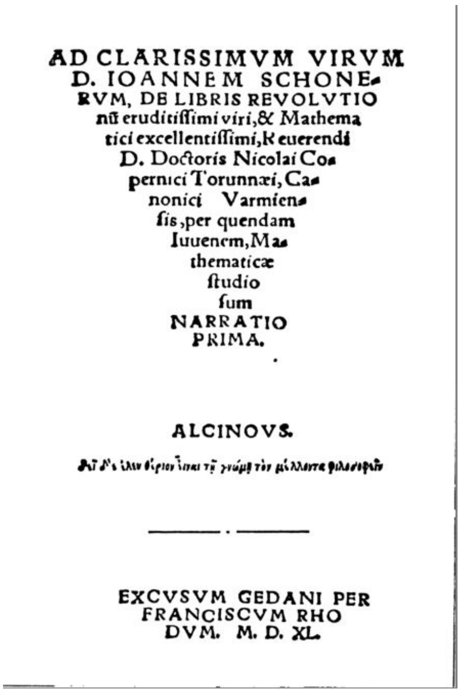
"All (...) the phenomena are admirably linked with each other as if by a golden chain. Each planet, by its place, course, and each change of its motion, provides evidence that the Earth is moving. And we, who inhabit the terrestrial globe, instead of accepting that its position is changing, believe in the wandering of the planets (celestial bodies) that reflect its motion."

As assessed by Noel Swerdlow in 1992: Copernicus could not have wished for a more learned, elegant and enthusiastic introduction of his new astronomy into the world of writing: *in fact*, Narratio Prima remains the best introduction to Copernicus's work to this day." Rheticus sent a copy to Schöner of course, and also to Petreius, who found the dissertation magnificent. Here is how he himself expressed his satisfaction:

"I have heard of the fame of Master Nicolaus Copernicus in the northern countries, and although the University of Wittenberg has made me a public professor of these sciences, I would not have thought I could be satisfied until I have learned something more through the information from this man. I will also say that I do not regret any financial expenses or a long journey, or other hardships. On the contrary, it seems to me that I have received a great reward for these troubles, namely, because I, an averagely talented young man, induced this honourable man to make his ideas in this area available to the whole world sooner."

In August 1541, Rheticus leaves Frombork with the manuscript of *De Revolutionibus* that he has received from Copernicus. In Königsberg he gives Prince

Albrecht a copy of his work over the map of Prussia and gains support for the publication of Copernicus's work. In October, he returns to Witttenberg, where he becomes the dean of a faculty. Faced with the harsh criticism of the heliocentric system by Luther and Melanchton, he teaches astronomy according to Ptolemy. He publishes the first geometric part of Copernicus's work, adding the world's first trigonometric tables (without the names of the *sine* and *tangent* functions as used today and the *secant* introduced by Copernicus). In 1542 he moves to the University of Leipzig. In May, he travels to Nuremberg and commissions Schöner and Petreius to publish Copernicus's work *On the Revolutions*. Lectures in Leipzig make it impossible for him to keep an eye on the printing. Eventually, in 1543, *De Revolutionibus Orbium Celestium libri sex* is released in Nuremberg with a preface and the title changed by Ossiander, the chief pastor of Nuremberg (it was supposed to be *De Revolutionibus coelestibus*). Sent to Frombork the work finds Copernicus on his deathbed.


AD CLARISSIMVM VIRVM D. IOANNEM SCHONERVM, DE LIBRIS REVOLVTIONŪ eruditiſſimi viri, & Mathematici excellentiſſimi, Reuerendi D. Doctoris Nicolai Copernici Torunnæi, Canonici Varmienſis, per quendam Iuuenem, Mathematicæ ſtudioſum NARRATIO PRIMA.

ALCINOVS.

EXCVSVM GEDANI PER FRANCISCVM RHODVM. M. D. XL.

Figure 16. *Narratio Prima* – the title page and the printer's imprint (reprint of 2009 from the author's collection)

The later life of Rheticus was lived far away from Gdańsk. The professorship in Leipzig is interrupted in 1551 by a moral scandal in consequence of which he flees to Chemnitz, then to Prague, where he studies medicine. In the years 1554-1574 he lives in Krakow. He works on 10-digit trigonometric tables with the values of sines, tangents and secant angles every 10". In 1574 he leaves for Košice, where he dies.

As far as the subject of this book is considered, the two most important achievements of Rheticus are:

1. *Narratio prima* published in Gdańsk which owing to the simple language gained more fame (four editions in the 16^{th} century) than Copernicus's work which it was promoting;
2. Measurement of the magnetic declination which initiated the world's oldest curve of its changes.

18. Bartholomäus Keckermann

The greatest fame among the professors of the Academic Gymnasium of Gdańsk was gained by Bartholomäus Keckermann (1572-1609). Having graduated in Germany, he declined the offer to take the chair in Heidelberg and returned to Gdańsk, where he contributed to the establishment of the Department of Law and History. His lectures on philosophy attracted listeners from Poland and abroad.

His works concerned logic (the first history of logic in the world), mathematics, geometry, optics, astronomy and geography, ethics, politics, economics, philosophy, metaphysics, rhetoric and physics! If we add thereto his navigation lectures, for the first time in Poland, the *System of Theology* published in Germany, and the ensuing *Introduction to the Study of Cicero's Writings*, we can claim that Keckermann was one of the most versatile scholars of his era. After his death, it was written: "Great were you with your writings, and since greater you could not be, the Heavens have let you to depart to God". The epitaph in the Holy Trinity Church reads [Fig. 17], *inter alia*: "To the outstanding philosopher and theologian who has laid his mortal remains in this place, who has given his spirit to the Heavens from which he came and who has devoted the fame of his name to eternity. This "monument of the love of his fellow human beings and universal grief" was founded in 1623 by "Joan Caspar Cirenbergius".

19. Philipp Clüver

Philipp Clüver (1580-1622), son of a merchant from Chlebnicka Street, and nephew (son - according to some authors) of the famous coin master - also Philipp, enjoyed no less fame than Keckermann [Fig. 18]. His signed his name in Polish as Kliwer. As a boy, he spent some time at the court of Sigismund III in Krakow. He commenced his studies in Gdańsk and continued his education in Leiden. He abandoned the studies of law preferred by his father and turned his attention to history and geography taught by Joseph Scaliger.

During his numerous travels he walked on foot (!) across England, Scotland and France as well as Hungary and Bohemia where he enlisted in the army to fight the Turks. Having returned from Leiden, he was given a special appointment as an academic geographer, a position created especially for him, after which continued his wanderings across Italy and Sicily.

Figure 17. Keckermann's epitaph in the Holy Trinity Church (Photo: Januszajtis A.)

Clüver was the founder of a new branch of knowledge - historical geography. His six-volume *Introduction to General Geography (Introductio in Universam Geographiam)*, published posthumously in the years 1624-1629, served for over a hundred years as a basic textbook at European universities (also at the Jagiellonian University in Kraków). His earlier works include *Germania Antiqua* (1616), *Siciliae Antiquae libri duo* (1619), *Sardinia et Corsica Antiquab* (1619) and *Italia Antiqua* (1624). He was the first to recognize the Urals as the eastern border of Europe. Whenever we say "ancient history," we repeat the term coined by Clüver.

20. Peter Krüger

Peter Krüger (spelled also as Crüger; 1580-1639), professor of the Academic Gymnasium, was one of the world pioneers in mathematics. He was born on 20 October 1580 in Königsberg. His father, Wilhelm, was the deacon in the Old Town church, his mother, Dorothea née Werner, came from Dryfort, today's Sroków, where her father was the mayor and where little Piotr grew up after losing his parents. From the age of 12 to 17, he was a dancer in the princely band in Königsberg, after which he entered the famous *Pedagogium*. In 1600 he stayed in Prague, where he established contact with Tychon Brahe and Johannes Kepler. From 1603, he was the preceptor of two young noblemen and together with them he came to Gdańsk to study at the Academic Gymnasium taught by the above-mentioned Bartholomäus Keckermann. After two years, he left for Wittenberg to continue his

Figure 18. Phillipp Clüver in 1620

studies crowned by receiving the Master's Degree after public disputes. Having returned to the country in 1607, he settled in Gdańsk and was hired by the Council as professor of mathematics and poetry at the Academic Gymnasium and as a certified measurer and proofreader of mathematical books prepared for printing. He also had the exclusive right in the city to make calendars and to the related title of the calendariographer, confirmed in 1623 by the privilege granted by King Sigismund III. In the years 1627-1630, a student of Krüger at the Gymnasium was Johannes Hevelius (see below) who devoted to him memoirs filled with gratitude. In 1608, Krüger married Elizabeth Reutorff and they had three sons and two daughters. After her death in 1625, he remarried Ursula Remus, with whom he had four sons and two daughters. His son and daughter from the second marriage were the only of his numerous off-springs to survive him. He died on 6 June 1639. He was solemnly buried in the the St. Trinity Church, probably under Tombstone No. 147. Still on his deathbed, he bound Hevelius to observe the solar eclipse (1 June) which he himself was too weak to do.

Krüger has left more than 20 scientific publications. His mathematical works are of the greatest value. The first of these (1607) was an attempt to square the circle (unsuccessful), however, the next attempt - *Sinopsis trigonometriae* (1612) – presented to Johannes Broscius on the occasion of his visit to Gdańsk, proves the author's great erudition and thorough knowledge. It contains basic theorems about triangles, names of trigonometric functions, tables of their values, and examples how to solve planar and spherical triangles. *Logistica sexagenaria* (1616), a treatise on the sexagesimal system, is also interesting, however, his most significant work is the *Practice of Logarithmic Trigonometry (Praxis trigometriae logarithmicae)* published in 1634 and reissued in 1648 and 1654 in Amsterdam. Having explained the basics of the theory of logarithms by Neper, Krüger presents logarithmic tables - the most detailed presentation in his time and the most accurate until the 19^{th} century. The first table contains the logarithms of integers from 1 to 10 000; the second - for the first time separately - the logarithms of the sines and tangents of angles at 1 minute intervals giving proportional parts for every 10 seconds, the third - the logarithms of sines of the angles from 0° to 90° at intervals of one second! The author added a fourth table, compiled by Jacobus Bartschius (Kepler's son-in-law), with logarithms of cosines of angles every 2 seconds from 0° to 1°41'. Krüger explained that he used the less convenient Neper system although the Briggs logarithms were already known because it was the Neper logarithms only that were used in the Rudolphine Tables used in astronomy at that time. In the same work he was the first to formulate the law of cosines in the form:

$$\cos\beta = \frac{a^2-(b+c)\cdot(b-c)}{2ac}$$

where a, b, c are the sides of a triangle, and β is the angle opposite to side b. Krüger's formula can be easily reduced to the one that we learn at school:

$$b^2 = a^2 + c^2 - 2ac\cos\beta$$

Krüger's other mathematical works include an outline of spherical trigonometry, *Doctrina astronomiae sphericae* (1635). His *Account Book (Rechen-Buchlein)* the popularity of which is evidenced by subsequent editions from 1631, 1635, 1642 and 1648 also deserves attention [Fig. 19]. This small piece of work continues to amaze to this day with the dexterity of the approach, high educational values and the apt choice of examples. "To devote here too many words to the praise and usefulness of the art of calculation is as if to try to help the sun at a bright noon by putting out a candle" - says the author in the introduction. He continues to refer to his over twenty years' teaching practice - also private. Subsequent chapters are devoted to the four operations on integers and fractions, and the simple, inverse and compound rules of three. He considers separately the money and the units of measurement and weight used at that time as well as some elementary commercial concepts. Here is an example of a problem, one of many, that his students, future merchants, had to solve: A servant of a Polish master has 800 zlotys in his pocket for which he is to buy red, blue and green cloth, the same amount of each as of the other; an ell of red cloth costs 5½ zlotys, blue 3¾ and green half of what the red one costs. How many ells of each sort will he get?" Then, there is a hint which shows what a great teacher he was: "It is not as difficult as it seems. Add all the prices up and you will get 12 zlotys for which (the servant) will get 3 ells, so it will be 200 ells for 800 zlotys which have to be divided into 3 portions".

The importance of Krüger's achievements in other fields cannot be denied. Research of terrestrial magnetism should be mentioned in the field of physics to which he devoted his work *De motu magnetis* (1606 and 1615). In the book he describes, *inter alia*, magnetic declination measurements to which he later encouraged Hevelius - the future discoverer of its variability over time. In astronomy, he was distinguished by his observations of comets which he started already under the supervision of Keckermann (treatises of 1605 and 1618), and the design of instruments such as the sextant admired by his contemporaries. Krüger also used the armillary sphere and he built sundials. His handwritten notes on the copy of *De revolutionibus* by Copernicus surviving to this day show that he had given up the cautious views of his young years (treatises of 1614 and 1615) and became a supporter of heliocentrism. He synthesized his astronomical views in the calendars which he published in 1608-1639 and in *Cupediae astrosophicae Crugerianae* (1631). The basics of geography, *Geographiae methodice discende typus* (1635) presented by him in a tabular way are also of some importance.

As a professor of poetry, he was obligated to write occasional poems. He did it willingly and not without talent, showing intelligence and knowledge of human affairs. About 20 German and Latin epigrams have survived and they differ in mood and form.

Ein Newes
Rechenbüchlein
Auff der Feder/
In ordentliche Capitel vnd gewisse Regeln verfasset/ auch mit gnugsamen dieser Lande bräuchlichen Exempeln erkläret vnd an Tag gegeben
Von
M. Petro Krüger/ Königl. Stadt Dantzig Mathematico.
Mit Königl. Privilegio.
16 31.
Dantzigk/
Gedruckt durch Andream Hünefeldt Buchhändler.

Figure 19. Krüger's *Rechen-Buchlein* (original copy in the Gdańsk Library of the Polish Academy of Sciences)

Krüger's duties as the city land surveyor included also preparing maps and plans. By 1615 he had surveyed Wielka Olszynka (Gross Walddorf) and Mała Olszynka (Klein Walddorf), Nowiny or Nowa Wieś (Neuendorf, today Dobrowo) and Płonia (Plehnendorf), belonging to the Construction Office - 131 lans, 20 morgens and 100 rods" without springs, dams and dikes". A plan of Stare Przedmieście (Old Suburb) prepared by him in 1617 has survived in the Gdańsk Archive. And in 1624 he measured the gardens in Podlice in Tczew (Dirschau) "which at first aroused many problems among the inhabitants, but they were successfully overcome and each owner had his modest plot of land surveyed".

Krüger, a hardworking and modest man, was commonly liked. Upon death the city and his friends were in deep mourning and grief. The most famous of them, the poet and royal secretary Martin Opitz, honoured the memory of the deceased with a beautiful poem - the last one in his life - which has been translated into English below:

Earth is not alone to show you its grief
*Which deems you O! K*rüger an honour to be
The stars, they are weeping, the sun's shining rays
Went through an eclipse ere you ceased your days
The Glory of Time and the Pride of the Town
The Earth had no qualms before you to succumb
You measured it up, as the heavenly ways
Gave you the fortune to show their trails
God knew how obedient you were with His laws
What you deserved you get back from all:
The Earth gives you rest, the heavenly vault
the name that shant perish, God gives you salvation.

It would be hardly possible to render more aptly the merits of the great professor of the Gdańsk Academic Gymnasium.

21. Johannes Hevelius

Krüger's student was Johannes Hevelius (1611-1697), the most outstanding astronomer after Copernicus [Fig. 20]. He studied in Leiden, like many citizens of Gdańsk at that time. In 1641 he constructed the famous astronomical observatory on the roofs of the houses on Korzenna Street, one of the first observatories in the world equipped with telescopes. One of these telescopes, installed on a plot of land owned by the astronomer in the suburbs was the largest telescope in the world at the time - it was 45 meters long. Hevelius's scientific activity was supported by the kings of France and Poland. In recognition of his achievements, the Royal Society of London appointed him its foreign member. The scientist's output includes 19 works, 28 dissertations and 16 volumes of letters. Hevelius developed the most accurate maps of the Moon at the time, determined the positions of 1,564 fixed stars, and introduced twelve constellations to the sky maps.

He was the first to use a micrometer screw to precisely adjust instruments. He invented the periscope. He also built prototypes of pendulum clocks - simultaneously with Huygens. By systematically measuring the magnetic declination, he discovered its changes over time and became a co-creator of the world's oldest curve of the change of declination, started in Gdańsk in 1539 by Joachim Rheticus. The illustrations of many of his works made by Hevelius himself are of high artistic value.

Figure 20. Hevelius (Schultz D., 1677, the original in the collection of the Gdańsk Library of the Polish Academy of Sciences)

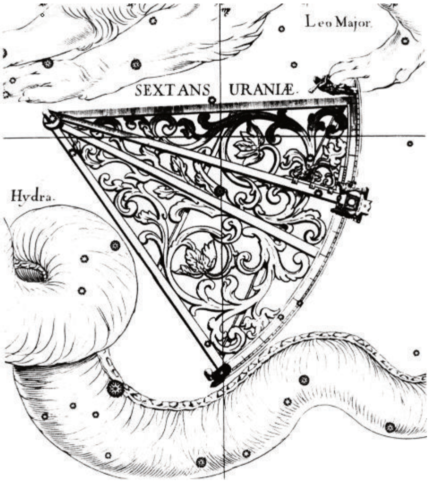


Figure 21. Hevelius's sextants (here on the map of the sky) are real works of art (*Prodromus Astronomiae*, Gdańsk Library of the Polish Academy of Sciences)

Let us move to the life history. Jan Heweliusz, as we call him in Polish, Johann Hewelcke in German, Johannes Hevelius - as he most often called himself in Latin, was born on 28 January 1611 in Gdańsk, in his family house at Grobla IV, on the corner of Straganiarska Street, under the then number 7. His parents were a wealthy brewer Abraham Hewelcke and Kordula née Hecker. He was baptized in St. John's Church. At the age of seven, he started to study at the Academic Gymnasium. According to his contemporaries, the future astronomer was a good student. "As his outstanding talents had been noticed since the sensitive childhood, he was urgently sent to school, where he learned the basics of Latin.

The mysterious enrolment of 11-year-old Hevelius at the "Albertina" University in Königsberg for studies which may not have been completed dates from 1622. In 1624 the plague forced the authorities to close the Gymnasium. To protect their thirteen-year-old son son against illness, the parents sent him to Gądecz near Bydgoszcz (Grudziądz (Graudenz) according to some) where he was to improve his Polish. After three years, he returned and started the second stage of education pursuing an individual course of studies, under the supervision of Peter Krüger. According to Pastor Barth, the author of the posthumous speech, Hevelius "having returned from Gądecz, continued his studies at the local Academic Gymnasium, where he diligently attended both private and public lectures, and he was liked very much by the professors of that time, especially by Mr. Krüger who also noticed that (...)with his zeal for other free sciences, he had a particular predilection for mathematics, as of 1627, in the sixteenth year of his life, he devoted himself to his detailed teachings and learned the basics of arithmetic, geometry, gnomonics, trigonometry, spherics, chronology and astrology". It should be explained that gnomonics is the art of building sundials, the term spherical should be understood as spherical trigonometry, and "astrology" is, of course, astronomy. Hevelius remembered Krüger with the highest esteem: "At that time, Professor Dr. Petrus Crüger lived in Gdańsk and was active in the public Gymnasium, a man of a sharp mind, a rare talent for teaching and of a cheerful disposition. Without neglecting secondary activities in other disciplines, I enjoyed his teachings with great joy ..." Krüger - an outstanding mathematician whose achievements have already been mentioned – focused Hevelius's interests on astronomy, which he practiced by making observation instruments himself [Fig. 21]. While encouraging his extraordinary student to pursue this field, he did not neglect to develop his other talents: The better the progress in the study of mathematics,“ writes Hevelius, ”the more earnestly Crüger was trying to convince me I should pursue the art of drawing to learn not only some technical tricks, but systematically how to draw. The result of these teachings is best evidenced by a later opinion by John Flamstead: "He aspires to be an artist among astronomers".

After such preparation, Hevelius had no problems at the famous Leiden University, which was most often attended by citizens of Gdańsk. The recent discovery of evidence of his earlier stay in Jena requires further investigation. In 1630 he was sent by his parents to Leiden to prepare for a merchant career, which gave him a chance to possibly become a member of the Gdańsk Council in the future. In principle, it was the study of law, however, the young man used his sojourn at the famous university to study optics and mechanics, and to establish contacts with prominent scientists. After a year - to strengthen those ties - he set out on a journey across Western countries which was typical for young people from wealthy families in Gdańsk. The itinerary planned in advance took him to London, Paris and Avignon. His knowledge, eloquence and manners must have made a great impression on the famous scholars whom he met at that time such as John Usher, John Wallis, Samuel Hartlieb, Marin Mersenne, Pierre Gassendi, Ismael Boulliau and others. Lasting friendships formed at that time bore fruit in many years of correspondence, exchange of ideas and scientific achievements. He was to go also to Italy to meet Galileo, but his father's illness - perhaps less serious than presented to him - forced him to interrupt the useful but costly journey. Coming back to the country in 1634, the 23-year-old young man was no longer unknown to the world. When he had returned, he took up the family business. In 1635, in St. Mary's Church, he married Katharina Rebeschke, who brought as a dowry houses in the Old Town (47, 48 Korzenna Street), a brewery, a granary and an adjacent plot (at Bednarska Street). Perhaps, he would have spent the rest of his life as a brewer and possibly a member of the city government, but an event occurred in 1639 that finally put him on the path of astronomy. The terminally ill Professor Krüger asked his former student to replace him to observe a total eclipse of the sun which was supposed to occur in a few days' time. It did happen, and from then on Hevelius devoted himself to science, without giving up other matters though, as long as they would not be in the way: *inter alia*, in 1640 he was elected alderman of the Old Town and the superior of the community of St. Catherine's Church, in 1643 – he became the elder of the beer brewing guild and the superior of the Elizabethan Orphanage, in 1651 – a councillor of the Old Town where he would usually chair the Council. He began with building the Star Castle (Stellaeburgum) - an observatory installed on the roofs of his houses at Korzenna Street, which started to operate in 1641. It was the first huge, regularly operating, well-equipped observatory in Europe - including lunettes [Fig. 23]. It did not take long to wait for the results. In 1647, *Selenography* dedicated to the Gdańsk Council was published, in which Hevelius included a description of his astronomical instruments and the results of his observations of the Moon, as well as the most accurate maps of the Moon at that time, with names given by the astronomer, some of which are still used today. While drawing them, he started the screen projection method. He developed a method for determining the height of lunar mountains. He discovered the longitudinal libration of the Moon (a kind of swaying during the revolution around the Earth) owing to which we can see a little more than half of its surface. The instruments, partly of his own design, allowed him to locate the position of stars and planets with an accuracy of 1 arc minute. Let us remember: a full circle is 360 degrees of 60 minutes of arc, or 21 600 minutes of arc. Hence, such accuracy means an error of 1/21 600, or about five thousandths of a percent. It was the maximum accuracy possible when viewed with the naked eye. Hevelius owed it not only to his legendary sharp eyesight, but also to the excellent workmanship of the instruments in which the only limitation was the diffraction (bending of light rays). In his catalogue, he included 1564 fixed stars (1538 measured personally by him) – 50 percent more than his predecessors. He was the first to present them with the so-called equatorial coordinates. When examining sunspots, he discovered the so-called solar hot spots– brighter spots. He introduced 12 new constellations to the maps of the sky, nine of which are used to date, including *Scutum Sobiescianum*. He discovered the phases of Mercury and the time variability of the Omicron star in the Whale constellation. Doubtlessly he was one of the greatest astronomers of his time.

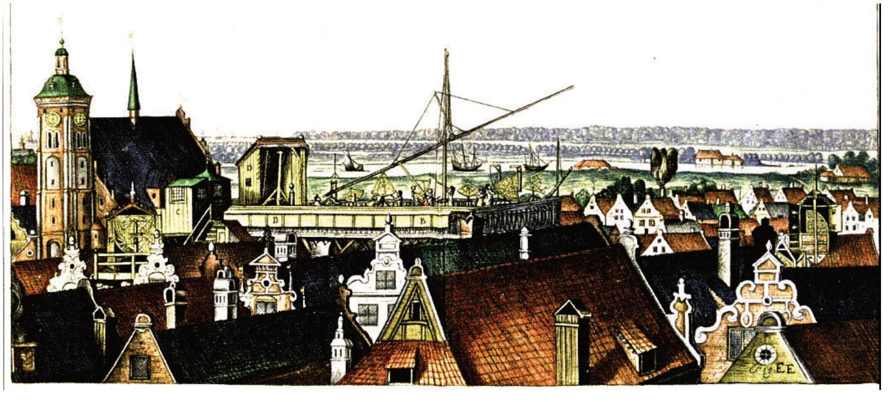


Figure 22. Hevelius's Observatory (*Machina Coelestis*, Gdańsk Library of the Polish Academy of Sciences)

After his father's death in 1649, he inherited the house at 49 Korzenna Street, and the brewery at Piwna Street, a suburban brickyard and a horse farm after his mother's death (1653). In 1659, he is honoured by a visit by King John Casimir and Queen Marie Louise Gonsaga. In 1660 he receives nobility (not confirmed by the Seym) and real estate. The observatory was visited by Christina, Queen of Sweden. In 1662, Hevelius's wife Catharina dies.

In the following year, the astronomer marries Elisabeth Koopman, who was 36 years his junior and who would become his best aide and assistant [Fig. 24]. His intensive work wins him worldwide recognition. King Louis XIV of France gave him a stipend, payable until 1672. In 1664, the Royal Society of London admitted him as its Fellow. In 1664, Hevelius's son Adeodalus (Bogdan) is born but dies after a year. Three daughters are born: Catharina Elizabeth 1666, Juliane Renate in 1668, and Flora Constantia in 1672. *Cometography* is published in 1668, and the first part of *Machina Coelestis* is released in 1673. Contacts with John III Sobieski started following his visit at the observatory in 1673 – to whom the scientist sent three lemons from a tree he had grown himself when he became king. John III repays him with the beer brewing tax exemption (in 1677) and a salary paid from 1678. In 1679, Edmond Halley, sent by the Royal Society, arrives, confirming the accuracy of Hevelius's observations. In the same year, fire destroys the houses, the observatory and almost all of the freshly printed second part of *Machinae coelestis.* The king's financial assistance and the energy of his young wife help restore the damage. In 1684, the grateful astronomer puts the *Scutum Sobiescianum* constellation on the maps of the sky.

Figure 23. Bust of Elizabeth Koopman (lost)

Interesting evidence that Hevelius was involved with various affairs of the city was the Memorial prepared by him in 1677 concerning a device for mountain levelling. A type of a transporter to carry the soil taken from the top of a hill to another place is described in it. Four horses harnessed to a treadmill could, as Hevelius writes, drive up to 150 wheelbarrows full of soil. We do not know whether it was his original idea or a description of an invention used in 1669 at the construction of the Notzke Bastion.

In 1687, on the day of his 76^{th} birthday (28 January), Hevelius dies of a kidney disease. After the astronomer's death, the widow compiled the materials left by him and published the *Catalogue of Fixed Stars (Catalogus stellarum fixarum)* in 1687, and in 1690 the *Sobieski Firmament (Firmamentum Sobiescianum)* with 56 maps and the *Herald of Astronomy (Prodromus Astronomiae)*, dedicated to King John III. The dedication was signed by "Elisabeth, the widow of Hevelius".

She died in 1693 outliving husband by six years. She was buried next to him in the family tomb in St. Catherine's Church in Gdańsk. François Arago, the prominent French scholar, wrote about her: "A reverent memory is always due to Mrs. Hevelius, the first woman I know, who was not afraid to bear the burden of astronomical observations and calculations."

Notwithstanding Hevelius's great services for the city and the world of science, it was as late as in 1780, only when Johann Bernoulli had expressed his surprise that such a great citizen of Gdańsk had no monument in the city that the astronomer's great-grandson Daniel Davisson, funded the epitaph in St. Catherine's Church – by the chisel of Wilhelm Christian Meyer. In 1790, King Stanisław August donated a bust of Hevelius sculpted by Andre Le Brun as a gift to Gdańsk.

Figure 24. Glaser's sundial design in the Gdańsk Archives (APG, Guide)

Hevelius and the sundial at the Town Hall. The sundial seen today on the Main Town Hall may be associated with Hevelius's presence. It was founded by Alexander Glaser, the learned preacher of St. Barbara's Church on Długie Ogrody Street. The colour design of the dial made by him in 1588 with the lines of "equal, unequal, Polish and Italian" hours has been preserved in the Gdańsk archives [Fig. 24]. It is the so called southern clock, i.e., facing directly the south. The shadow of the gnomon set parallel to the Earth's axis, assuming the latitude of 54°54' (in fact it should be 54°21') measures the local solar time on the hour lines. The unequal hours are a remnant of the early Middle Ages, when the day and night were divided into 12 hours - from sunrise to sunset and from sunset to sunrise. The Polish hours were counted from sunrise, and the Italian hours - from sunset on the previous day. The lines of each hour type are marked with Arabic numerals in the appropriate colour. The numbers are 1 to 12 for unequal hours, 1 to 11 - for the Polish hours, 13 to 24 for the Italian hours. All three types of hours are indicated by the shadow of the ball on the gnomon on the appropriate lines. In addition to that, the dial has lines to read the position of the Sun in the Zodiac, and also indirectly the months. The signs of the Zodiac are painted on the edges of the inner green field of the dial. The summer and autumn signs are on the left, and the winter and spring ones on the right: During the day, the shadow of the ball is travelling from left to right along a line corresponding to the season: above the centre line corresponding to the equinox in autumn and winter, and below it in spring and summer. The extreme bottom line corresponds to the summer solstice, the extreme top line to the winter solstice. The centre of the dial is adorned with the coat of arms of Gdańsk with the date: 1588. The lines of the equal hours come out from the image of the Sun. The inscription reads: "Our days are shadows" (VMBRA SVNT DIES NOSTRI). At the bottom of the dial we read: M. ALEXANDER GLASERVS F. ET DDIC: (*fecit et dedicavit* - made and offered by).

Figure 25. Glaser's sundial at the present time (Photo: Januszajtis A.)

The dial of the current sundial differs slightly from the original design [Fig. 25]. The hour lines are the same but placed slightly differently. The equal hours are now marked as "astronomical", and the Polish hours - as "Babylonian". There is no coat of arms of Gdańsk in the centre of the dial, but it has appeared above the dial instead - beautifully composed, though not entirely accurate: it is a heraldic error to place the crown over the shield, instead of - as required by the privilege of Casimir IV Jagiellon - in the upper part of thereof. The upper inscription only has remained from the two inscriptions in the frames: "Our days are shadows". These changes are explained in the books of Kamlaria (the Municipal Treasury) in the fiscal year 1647/1648 under the entry the "Sundial": "the painter Izrael Leon for painting the sundial completely anew on copper plates - 180 marks (monetary unit, equivalent to about 200 g of silver), decorating two lions and the city's coat of arms above the sundial – 45 marks, Hans Miebis for the two copper lions – 135 marks, Wolfgang Günter, the sundial maker for all the works on the sundial - 150 marks, Jan [Jean] Charpentier for the iron triangle [gnomon] - 3 marks, Jerzy [Georg] von Strackwitz [Strakowski] for some expenses related to the sundial – 9 marks". The cost totalled 558 marks. Further renovations did not bring any fundamental changes.

The sundial on the painting *Rental Groschen* by Antoni Möller of 1601 is similar to Glaser's design. Therefore, the changes must have been made during the renovation. Why were they made? Most probably the idea was to improve the indications. We know that Wolfgang Günter was a close associate of Hevelius. The astronomer was interested in gnomonics – he is known to have designed a magnificent sundial for the palace in Wilanów (Sobieski's palace near Warsaw). As the Old Town councillor, representing it in the Main Town Hall, he was often at the place and could not help noticing the incorrect latitude of Gdańsk assumed by Glaser. It is quite possible that the design of the revised sundial was developed by or at least consulted with him. Let us add that the correct latitude was determined for the first time by Hevelius's teacher, Peter Krüger.

A Coryphaeus of Idea. Hevelius was a true light of his time. He did not lock himself up in an "ivory tower", but spread the scientific ideas in his environment and in large circles of his correspondents. Hevelius's circle included the Gdańsk physician Israel Conradt, who, in a series of lectures delivered in 1670, presented the results of his own research on the effect of low temperature on the state of matter. The text published seven years later includes, *inter alia*, a description of the phenomenon of liquid supercooling discovered by the author. Conradt carried out his research in response to an appeal from the Royal Society of London. Such an appeal may have been communicated to him by his friend Hevelius, who was in regular contact with the Society of which he was a member. It can be assumed that Hevelius had a significant share in Conradt's proposal to establish a scientific society following the example of Italian academies. The project was rejected by the Conservative Council, however, the idea of Hevelius and Conradt was still alive and finally - in 1720 - it was implemented when the Scholar Society (*Societas Litteraria*) - the first in Poland, and then - in 1743 - the Society of Experimental Physics (Natural Science - Naturforschende Gesellschaft) were established. More information on this subject can be found in the chapter on scientific societies (p. 84 ff.)

A Pioneer of Physics. "A favourite of kings and dukes, the prince of astronomers," as the Gdańsk Council described him on a medal minted on the hundredth anniversary of his death, he was also famous in the field of physics. It is true that he is wrongly credited with inventing the micrometer screw, which had been known already in Heron's times. Hevelius improved it only and used it in an ingenious way by introducing a gear train to increase the accuracy of reading [Fig. 26]. However, an unquestionable invention of his was the polemoscope, i.e. the periscope: "I invented and built this optical instrument myself in 1637, and I do not think that it had been seen ever before (let it be said without boasting) " [Fig. 27]. We also know that he would build first prototypes of pendulum clocks in Poland [Fig. 28]. At this point another

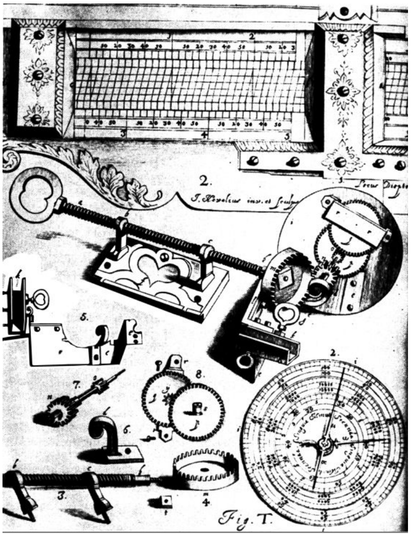


Figure 26. Hevelius's micrometric screw (*Machina Coelestis*, Gdańsk Library of the Polish Academy of Sciences)

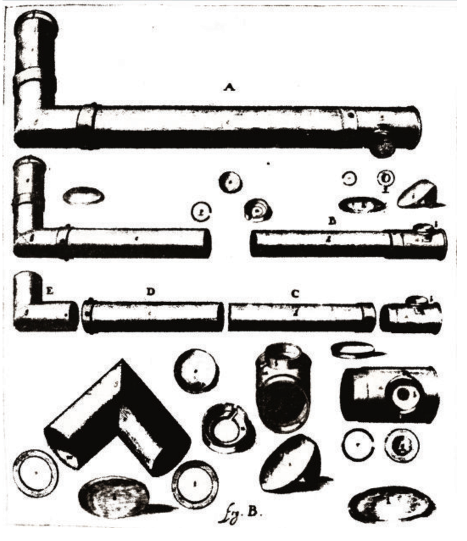


Figure 27. Hevelius's polemoscope (*Machina Coelestis*, Gdańsk Library of the Polish Academy of Sciences)

of his achievements in the field of physics should be mentioned. For many years, Hevelius would measure the magnetic declination with an incredible accuracy for his time, and he can be considered to have discovered or co-discovered its changes over time. For the sake of accuracy it should be added that Hevelius made his first measurement in 1628 under the supervision of Krüger, who, even if he had not known Rheticus's result (over 13°E), must have noticed a significant difference compared to his measurement from 1600: here 1°W, there

8½E. Gdańsk was exceptionally privileged in this respect indeed, as it was here where one of the first measurements of declination in the world was made. As has been mentioned before, it was done in 1539 by Joachim Rheticus - a student and assistant of Nicolaus Copernicus, who came to the city to see to the publication of the *First Account (Narration Prima)* devoted to his Master's system. The next measurement was made around 1600 by Peter Krüger. Hevelius began the series of his measurements in 1628 as a junior high school [gymnasium] student under the supervision of Krüger. It was his first research work. The last time when he measured the declination was in 1682. Thanks to this wonderful series of seven measurements, we have in Gdańsk the oldest magnetic declination curve in the world [Fig. 29].

The discoverer of changes in declination over time is considered to be Henry Gellibrand (1635). The actual discoverer may have been Krüger, but it was Hevelius who realized the significance of this observation and described it. This is evidenced by a fragment of a letter from 1670: "The changes in the magnetic declination over time discovered by me have been sufficiently confirmed by observations of the famous Englishmen: Burrow, Gunther and Gellibrand."

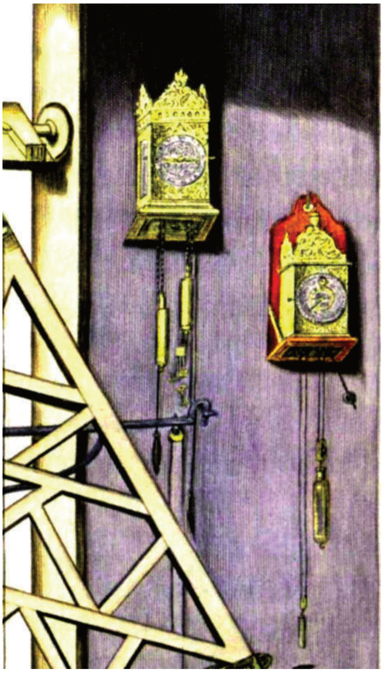
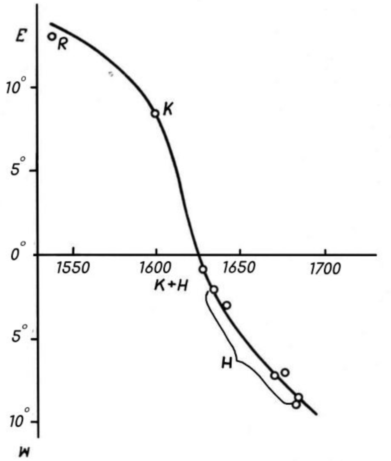


Figure 28. Hevelius's clocks (*Machina Coelestis*, Gdańsk Library of the Polish Academy of Sciences)

Jan Heweliusz, Johannes Hevelius or Johann Hewelcke? Hevelius was born and baptized as Hans or Johann Hewelcke (Hewelke in some more recent records). This was announced by Andreas Barth, the pastor of St. Catherine's



5. Wiekowe zmiany deklinacji magnetycznej w Gdańsku
R — Retyk, K — Krüger, H — Heweliusz

Figure 29. Gdańsk magnetic declination curve
Changes of magnetic declination over time in Gdańsk
R – Rheticus, *K* – Krüger, *H* – Hevelius

Church during the mourning speech. In everyday life the scientist would use German which was the language commonly used in Gdańsk. So why do we say and write "Jan Heweliusz" and not Hans, Johann or Johannes Hewelke? Recently, foreign names and surnames have been entered in records in the original language form, which sometimes leads to errors. For example, some authors refer to the creator of the Gdańsk Arsenal as "Anton" van Obberghen, while he himself signed with the name of Antoni, and in the contemporary documents he appears as Master (Meister) Anthoni – and never Anton! In the catalogue of students of the Academic Gymnasium in 1618, Hevelius was entered as Johannes Hefelke Dantiscanus, and as Hans Hövelke as a juror in the records of the Old Town authorities of 1641. As of 1651 the records contain the councillor: Johann Hövelke, Hovelke or Höfelcke. It was as late as from 1673 that the names Hevelke, Hewelke or Hewelcke start to prevail in the records. They all refer to the same person! No wonder that in scientific works and letters written in Latin, our astronomer decided to use one name: Johannes Hevelius. It happened during his studies in Leiden where the language of instruction was Latin, and it may have happened even at an earlier time, during his studies at the Academic Gymnasium, where it was forbidden to use other languages in higher grades.

How did Hevelius become Heweliusz? What worked here was the mechanism of adaptation of foreign sounding surnames which is typical for many languages. The Greek ending -*aios* was transformed into -*aeus* (pronounced -*eus*) with the ancient Romans which was then adopted by the entire Latin world. In Poland

Figure 30. *Scutum Sobiescianum (Firmamentum Sobiescianum*, Gdańsk Library of the Polish Academy of Sciences)

it was made Polish in the form of *-eusz*. In this way, Greek Ptolemaios and Latin Ptolemaeus have become Ptolemeusz, Italian Medici – Medyceusze, French Conde – Kondeusz, and Hevelius – Heweliusz. Names such as Tadeusz, Juliusz, and even Janusz from Latin Joannes or German Johannes have been made Polish in a similar way.

Figure 31. Hevelius's epitaph in St. Catherine's Church

Nonetheless, the form of Jan is more common in this case. We have the full right to use it also to people of foreign origin, especially related to Poland and widely known in our society. Hevelius was born in Gdańsk, thus, he was a citizen of the Polish Crown by birth, having equal rights with others on its

Figure 32. Hevelius's bust - a gift from King Stanisław August Poniatowski (Photo: Januszajtis A.)

territory. We also rightly name him the most famous astronomer of the Polish Republic after Nicolaus Copernicus, as he was described on a plaque placed in 1987 at the place where - as was believed at the time - his houses and his observatory were once located: at the corner of Korzenna and Heweliusza Streets. What did he think about it himself? His dedications to the highest rulers of Gdańsk – the Polish Kings, usually in Latin are significant in this respect: "To the Highest and Most Powerful Ruler and Lord, Joannes III by the Grace of God, King of Poland, Grand Duke of Lithuania, Rus, Prussia, Mazovia, the Lands of Kiev, Volhynia, Podolia, Podlasie, Smolensk, Siewierz, Czernichowszczyzna (...) Lord and King, always the Most Gracious". Similarly in the header of the letter: 'Your Royal Highness, Most Honourable Lord" How touching and subtle was the gift sent by him to Jan Sobieski when he heard that he had been elected king - three lemons from a tree that he had grown himself! And when in 1660 he was visited by John Casimir at the observatory who was delighted with the first pendulum clocks in Poland made under his supervision, one of which was "humbly and obediently" offered the King by Hevelius as a gift. In a letter to Adam Kochański dated 9 January 1681, he called himself (in Latin) "a citizen of the Polish world who had, for the glory of his Homeland and for the sake of science, did so many works and made so many efforts, without boasting, with the greatest input of his abilities". If we add *Stellae Vladislavianae* or *Scutum Sobiescianum* introduced by him to the maps of the sky which he named Sobieski's Firmament (*Firmamentum Sobiescianum*), there seems to be no need for any other comments [Fig. 30]. The Gdańsk Germans in those times were Polish Germans, and most of them were loyal citizens of the First Polish Republic.

Having reached the age of majority, they swore (in German) loyalty to the kings of Poland, and in times of unrest they kept their oaths more diligently than many Poles. The preserved texts of oaths speak louder than the contradictory learned interpretations of much later times. Even the oath taken on the ramparts during the rebellion against Stefan Batory in 1577 ends with the reservation: "Without harm to the eternal incorporation and the unification with the Polish Crown, while maintaining our lawful freedoms and privileges. So help us God and His Holy Word!". It is hard to find a clearer and more explicit formulation of the attitude of the old Gdańsk with respect to Poland.

Monuments. A distinct proof of the respect which is still enjoyed by Hevelius in his hometown are the monuments to him of which we have at least five. The epitaph from 1780 found on a pillar above his tomb in St. Catherine's Church should be considered to be the earliest [Fig. 31]. It was founded by his great-grandson Daniel Gottlieb Davisson, and it was carved in marble by Wilhelm Christian Meyer, a sculptor of Berlin, recommended by the astronomer Jan Bernoulli. A wooden canopy was added at Davisson's wish. Another monument, a master bust by Andre Le Bruno (currently in the National Museum in Gdańsk), was given to the city as a gift in 1790 by King Stanisław August Poniatowski [Fig. 32]. The third monument was erected in 1972 in front of a gymnasium school in Gdańsk Przymorze (at Zgody Street). The fourth monument, sculpted by Michał Gąsienica Szostek, was placed in front of the Old Town Hall in 1973. It was moved to its present location at Wodopój Street in 2006 to be replaced by the excellent fifth monument, the work of Jan Szczypka in front of the Town Hall [Fig. 34]. To honour the astronomer, students of the Academy of Fine Arts made a presentation of the sky on the wall of a building neighbouring on one of the houses at Korzenna Street. It is a fragment of a map of the constellations from Hevelius's epochal work *Machina Coelestis*. The sundial at the Great Mill, installed there by the team of Grzegorz Szychliński at the same time as the monument was unfortunately damaged by mindless vandals.

Let us mention three of the plaques dedicated to Hevelius: 1. a memorial plaque with the likeness of the astronomer has been in the Old Town Hall since 1911; 2. an inconspicuous bronze plaque on the corner of Heweliusza and Korzenna Streets (also an expression of remembrance) has reminded us since 1987 where his houses were located according to the knowledge at that time; 3. in 2011 a plaque was placed on Gymnasium No. 2 on Kartuska Street to commemorate giving the name of Hevelius to the school. Another effigy in stone has decorated the bay window of the building where the offices of the National Bank of Poland are located today at Brama Wyżynna (the Upland Gate) since 1906. Another magnificent monument to Hevelius is *Centrum Hewelianum*, a centre for the promotion of science at Grodzisko Hill (Hagelsberg). The numbers of painting with Hevelius has increased recently when the astronomer's face has been discovered in a crowd of figures on *Entry of Christ into Jerusalem* by Bartholomew Milwitz, painted in 1654 for St. Catherine's Church [Fig. 34]. Nonetheless, the greatest

Figure 33. Monument of Hevelius before the Old Town Hall (Photo: Januszajtis A.)

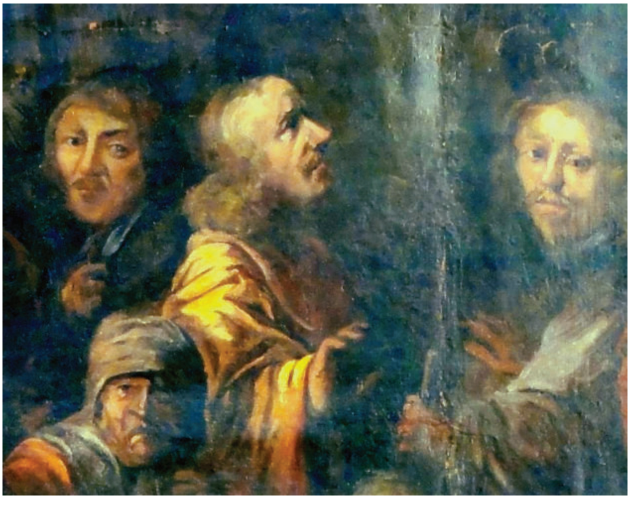


Figure 34. Hevelius in the painting by Miltwitz (Photo: Januszajtis A.)

portrait of him remains the masterpiece by Daniel Schultz, described above, found in the collection of our splendid Gdańsk Library (a copy of Andreas Stech's

Figure 35. Hevelius in the courtyard of his name in Gdańsk University of Technology (Photo: Krzempek K.)

portrait of astronomer sent by him to the Royal Society - now in Bodleyan Library in Oxford).

Johannes Hevelius is the patron of one of the roofed courtyards of the Main Building of the Gdańsk University of Technology - the one with the Foucault pendulum. In 2011, the astronomer's portrait adorned the recess behind the pendulum [Fig. 35].

22. Creators of the Gdańsk Pharmacopoeia

When talking about the history of the Gdańsk science it is impossible not to mention medicine and pharmacy the progress of which played an important role in the development of chemistry. The first item of information about a pharmacy in Gdańsk comes from 1399. Professional physicians were already active in the city at that time. In city statutes, issued in 1455, regulations are found whereby the practice is conditional on the presentation of relevant certificates. The office of the city physician was in place as of 1500. The first information about an infectious diseases hospital, the so-called the House of Smallpox (Pockenhaus) - later the Municipal Lazaret comes from 1515. Doctor **Johann Brettschneider** (Placotomus, 1514-1577), associated with Gdańsk, published an apothecary manual in Antwerp in 1560. The first chair of anatomy in Poland operated in the Academic Gymnasium from 1580. In 1597 the Pharmacy Act was printed. In 1612, *Collegium Medicorum* was established - the first Medical Chamber in Poland. In 1613, Doctor **Joachim Oelhaff** (1570-1630) performed in Gdańsk the first public autopsy in Central Europe. In 1665, following the draft issued three years earlier on the initiative of the City Council, the first Pharmacopoeia, i.e. a collection of official recipes for medicines in Poland was prepared in Gdańsk. The Latin title can be rendered as follows: "The Gdańsk Dispensatory, containing all materials, both galenic and chemical, which are sold in the Gdańsk offices, created under the authority of the Illustrious and Most Distinguished Senate, prepared by the work and efforts of Doctor Johannes Ernest Scheffler and Doctor Johannes Schmiedt, the ordinary physici of the City". The word "physicus" meant in those days the doctor, "offices", of course, pharmacies, of which there were six in Gdańsk then. The profiles of both the creators of the Pharmacopoeia are presented below.

Johann Ernst Scheffler. He was born in Gdańsk on 17 July 1605, son of Christoph Scheffler and his second wife Maria Haderschlieff. Having graduated from the Academic Gymnasium, he studied medicine and philosophy in Louvain. He graduated in 1632 and received the degree of Doctor of Medicine in 1633. Then, he may have stayed at the Royal Court in Warsaw as he would boast to have the royal Polish doctor title. He was married three times. He had three children with his second wife, Susanna Maria von Peschwitz, the widow of Christian Esske. In 1658, two years after her death, he married Adelgunde from the old Gdańsk family von der Becke, the widow of Georg Wolfram. In 1661, he became the city "physicus" in Gdańsk. In 1665, jointly with Johannes Schmiedt, he developed the above mentioned Pharmacopoeia. Born into a Lutheran family, he converted to Catholicism. In 1663, he founded an epitaph for himself in St. Nicholas's church which was carved by Hans Caspar Gockheller, and in 1671 - three altars, one of which has been preserved. He was involved in a bitter dispute with Aegidius Strauch, a fanatical Lutheran preacher, and he wrote a devastating response to his anti-Catholic and anti-Polish statements. He died on 14 August 1673. A week later, against the will of the deceased (!), a Lutheran funeral was organized for him in St. Mary's Church.

A realistic likeness of Scheffler is glancing at us from the epitaph [Fig. 36]. The Latin inscription reads, *inter alia*: "Wherever we turn everything is uncertain, certain is only death whose eventual purpose is eternity. This is where we are going, running and hurrying, remembering Jan Ernest Scheffler, Doctor of Medicine, Physician of His Saint Majesty, who has made this mortal tombstone for himself in his lifetime from his income accumulated in mortality, for the happiness which he expects and is trying to enter. Below the inscription is Scheffler's coat of arms: two scheffels (grain measuring vessels, bushels) in a diagonally divided field. This is the so called speaking coat of arms which is related to the surname Scheffel in German where Scheffler is the person operating a Scheffel. The form of a portal hanging on the wall symbolizes the entrance to the world of eternity, the Phoenix in the finial - resurrection, the burning vases on the pillars - love for God.

On the preserved altar founded by him (St. Rose of Lima, with a painting by Andreas Stech), Scheffler is described as "a doctor of medicine, an ordinary physicist of the City of Gdańsk". His coat of arms is at the top and the figures of his patron saints: John the Baptist and Ernest are at the sides.

Johannes Schmiedt. He also signed with the Latin form of the surname **Fabritius.** He was born in Gdańsk on 1 December 1623. His father Daniel

Figure 36. Scheffler's epitaph in St. Nicholas's Church (Photo: Januszajtis A.)

was a doctor in the city service, his mother Catherina Schewecke came from a well-known patrician family. When he was seven, his parents sent him to Rudno near Pelplin for four years, where he lived with pastor Jan Schroeder who taught him Latin and Polish. Having returned to Gdańsk, he took private lessons, later he studied at the Academic Gymnasium. He became famous for the first oration in ancient Greek in the history of the university. Following his father's will who wanted him to be educated to become a theologian, in 1642 he began studying philosophy at the "Albertine" in Königsberg. It was there where he discovered the vocation to the family specialty (grandfather, father and uncle were doctors) and also attended medical classes. In 1646 he left for Leiden, where he studied botany and Arabic (!), then he travelled to Paris, Lyon and Avignon, and finally, to Montpellier to deepen his medical knowledge. It was there where he received his degrees of Bachelor in 1648 and Doctor of Medicine in the following year. He published several dissertations in which he argued, *inter alia*, against the use of the then fashionable bleeding to cure chronic diseases. Not only that: he also went to Padua for additional studies in anatomy, surgery, physics and chemistry! This trip lasted a year; then Schmiedt returned to Gdańsk and opened a private practice. His father, who had appreciated his achievements, died in 1651, his mother had been dead since 1649. In 1654 Johannes Schmiedt married Dorothea Wulff, the widow of the merchant Heinrich Borbeck, who died childless in the following year. In 1659, he married Anna Maria Riccius, the daughter of a trustee (legal council), with whom he had five children. He lived in his family house at 59 Piwna Street, on the corner of Kozia Street, the front porch of which was decorated with a magnificent baroque balustrade that has survived to this day. In 1664, he became the city "physicus". A year later - together with Johann Ernest Scheffler - he prepared the Dispensatorium (Pharmacopoeia). He was the first doctor in Poland and the third doctor in the world to apply intravenous injections - for the first time in 1666. After the death of his second wife in 1676, he remained single. He died on 3 March 1690. He was buried on 15 March of the same year in St. Mary's Church, in Tomb No. 182, which he had bought 30 years before. His son, Johann Gabriel, promised to be an outstanding scientist, but died of a lung disease in 1686, at the age of 24 - a year after receiving his Doctor of Medicine degree in Montpellier. The father was pain stricken with his death. His daughters, Anna Dorothea and Virginia Renata married doctors, the other two died in childhood. The scientific level of Johannes Schmiedt, in addition to his co-authorship of the *Pharmacopoeia*, is evidenced by 20 Latin dissertations, published e.g. in *Philosophical Transactions* - an organ of the Royal Society of London.

The evidence of his high professional position is the portrait by Andreas Stech, on the basis of which the posthumous engraving by Hainzelmann, preserved in Kraków, was created [Fig. 37].

Figure 37. Johannes Schmiedt (by Hainzelmann, acc. to Stech)

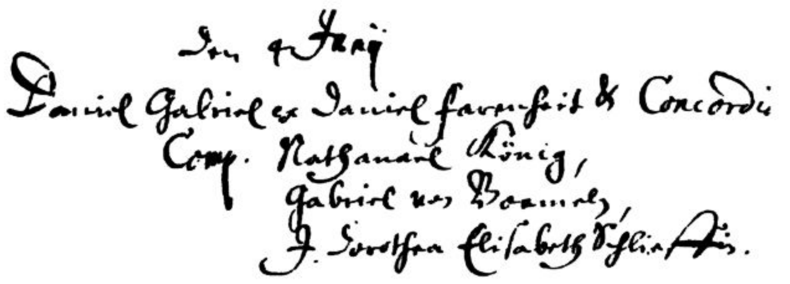
The *Pharmacopoeia* was not the only example of the collaboration between the two doctors. In 1651, they certainly did not remain indifferent to the renewed attempt to establish Collegium Medicum - a professional organization of doctors (the first organization, established in 1612 operated only for some time). It can be assumed that it was they, being well acquainted with the Western European models, who prepared the statutes of the organisation on such basis. However, similarly as in 1636, the city authorities rejected the project. It is almost certain that in 1670 both scholars supported the proposal of the above mentioned Doctor Israel Conradt to establish a scientific society similar to the Italian academies. Later, in 1677, after Scheffler's death, when 14 doctors again applied for establishing a Medical College, Schmiedt was the first to sign the petition. The City Council did not approve the undertaking this time, either.

Daniel Gabriel Fahrenheit. Daniel Gabriel Fahrenheit of Gdańsk (1686--1736), active mainly in the Netherlands, became famous as the creator of the first reliable thermometers (1708), which he filled with alcohol or mercury (1713), as well as the thermometric scale (1713; the scale was corrected by him in 1717 and standardized by the Royal Society in 1777), still used in the USA today.

LIFE HISTORY. Daniel Gabriel Fahrenheit was born in Gdańsk in 1686, son of Daniel Fahrenheit, a merchant and shipowner and Concordia née Schumann. After his initial education at St. Mary's School, he was to study at the Gdańsk Academic Gymnasium. These plans were destroyed in 1701 by the death of his parents. Having been sent to Amsterdam for mercantile practice, Daniel Gabriel, against his curators' wishes, devoted his time to the construction of scientific instruments. In 1708 he left for Copenhagen, where he conducted research under the supervision of Olaf Rømer. Having reached the full age, he returned to Gdańsk and collected his share of his parents' estate. He was involved in large-scale trade for a short time, but then returned to study. In 1712, he started to work with Paul Pater, the founder of the first technical school in Gdańsk and Poland. In 1713 he moved to Berlin and in 1717 returned to Amsterdam, where he spent the rest of his life. He conducted research, delivered private lectures, and built scientific instruments. He maintained contacts with scientists from various countries, and in 1724 he became a member of the Royal Society of London. He died in 1736 in the Hague, probably as a result of mercury poisoning. He is famous as the creator of the first reliable thermometers (1708), which he filled with alcohol or mercury (1713), as well as of thermometric scale (1717) still used in the USA today. Before 1723, he had discovered the dependence of the boiling point of a liquid on pressure. In the same year, he raised the boiling point of water by adding sea salt thereto. He explained both these phenomena with reference to the molecular theory. Fahrenheit was also a pioneer in low temperature physics: in 1729, using a cooling mixture he obtained the temperature of -40°, a record temperature at that time. His other inventions included medical thermometers, which he sold for a florin apiece, and a centrifugal pump for cleaning channels, for which he obtained a patent. The museum in Groningen has a perfect model of the eye made by him in its collection. Despite these achievements, he lived and died in poverty - he could not even afford a portrait.

DATE OF BIRTH. To find the full date of Fahrenheit's birth, let us have a look at the multi-volume Encyclopaedia of the Polish Scientific Publishers issued on the initiative of the daily *Gazeta Wyborcza*. However, we can find only the year there. The case is similar in other publications of this type, which are usually limited to giving the year of birth, death and other events from the life. Therefore, it should be sought elsewhere. It is not difficult to come to the conclusion that whenever the date of Fahrenheit's birth appears in Polish and German publications, starting with an anonymous sketch from the mid-18th century, it is 24 May 1686. The situation is different in English sources. According to the earlier editions of the famous British Encyclopaedia, Daniel Gabriel Fahrenheit was born on 14 May 1686 – later publications give the date of 24 May. The explanation is simple. Gdańsk, similarly to the whole of Poland, adopted the Gregorian calendar reform with its announcement in 1582. The Protestant England did not want to submit itself to the dictate of Rome and maintained the Julian calendar until 1752. The reason for the difference between the two calendars is due to the fact that Pope Gregory XIII cut out 10 days from the calendar: Friday, 15 October followed Thursday, 4 October 1582 (today this difference has gone up to as many as 13 days). In 1686, when it was 24 May in Poland, the same day in England was marked as 14 May. It follows from the above that both the Polish and English publications are right. However, the latter should include a note that the date is given in the Julian system. There are no problems with the date of his death: the scientist died on 16 September 1736 in the Hague. However, there is a problem with the grave. He was buried in the local "Monastery" church (Kloosterkerk), however, today his body is not there, because while modernizing the crypt (in the 19th century) the coffins were moved to the public cemetery. So far, attempts to establish the exact date of relocating the remains and the place of burial in the cemetery have been unsuccessful.

CHRISTIAN NAMES. The title of this section seems to be lacking sense: Daniel Gabriel is Daniel Gabriel. However, when we look up an encyclopaedia, we can have doubts. In some of them, our scientist is entered as Gabriel Daniel. Also on the Internet, which is otherwise full of errors, sometimes it is about Daniel or Gabriel Fahrenheit, and most often about Gabriel Daniel. The correct order of the names can be found in the books of St. Mary's Church, where Fahrenheit was baptized [Fig. 39]. Under the date of 4 June 1686 we read: "Daniel Gabriel ex Daniel Farenheit & Concordia" or "Daniel Gabriel (child) by Daniel Fahrenheit (the scribe misspelled the name - without the first h) and Concordia". The first name was given to the newborn after his father, the second - Gabriel - was popular with the Schumann family from which his mother came. As we can see, the proper names are Daniel Gabriel. Stating the name Daniel only is misleading as that was the name of the scientist's father, a well-known and respected merchant and shipowner, but only him. And which names were used by their owner himself? His signatures in different periods of his life always had the same form: Daniel Gabriel Fahrenheit. This is how he signed his letters, he made such a signature under the oath as a new member of the Royal Society of London. He would never change the order of his names. Sometimes he would use only the initials: D.G. Fahrenheit. Even on his deathbed, when fever had distorted his handwriting to the point of illegibility and affected by it he wrote "Farenheit" instead of "Fahrenheit", but he did not forget about the correct order of the initials: D.G.



Świadectwo chrztu Daniela Gabriela

Figure 38. Baptism certificate of Daniel Gabriel Fahrenheit in Gdańsk Archives

Hence: the correct names and their order are Daniel Gabriel Fahrenheit. Any and all other versions are incorrect.

FAHRENHEIT'S THERMOMETERS. The greatest achievement of Fahrenheit was the practical and theoretical development of the foundations for the construction of reliable thermometers, calibrated on the basis of three fixed points. In the notes from his lectures in Amsterdam in 1718, we find the following description of the characteristics of a good thermometer: 1. It must show the same degree of cold or heat with other ones at any time and place, i.e. thermometers must be the same. 2. It must have variations occurring within the limits of certain findings in the nature. 3. The changes must be seen as quickly as possible, i.e., it must be stimulated by the smallest change that occurs in the air and display it as quickly as possible. 4. The liquid with which it is filled must be connected with air. 5. The liquid must be coloured to a colour that does not change" (Ploos van Amstel). By the concept of limits of findings in the nature, Fahrenheit understood the fixed points used by him, namely: 1. The greatest cold in the surrounding atmosphere that can be found when certain amounts of water, ice and salt are mixed (...). 2. The melting and freezing points which are found by mixing water and ice (...).3. The living creature blood point, which, however (...) is unreliable. 4. The boiling water point".

The reaction speed could be increased thanks to the use of a cylindrical vessel: "Fahrenheit was the first to invent a thermometer of this kind and on 25 March (1718) he showed us clearly the difference in the following way: He took two thermometers with the same readings, one of which was fitted with a spherical vessel and the other with a cylindrical one, he placed both of them at the same height in the flame of a candle (...): it could be clearly seen that the one with the cylinder reacted much faster than the one with the ball, which is due to the fact that the cylinder (which was exactly of the same size as the ball) had a larger surface area than the ball and therefore was faster excited by the air, and as it had a smaller diameter, so it was easier to penetrate".

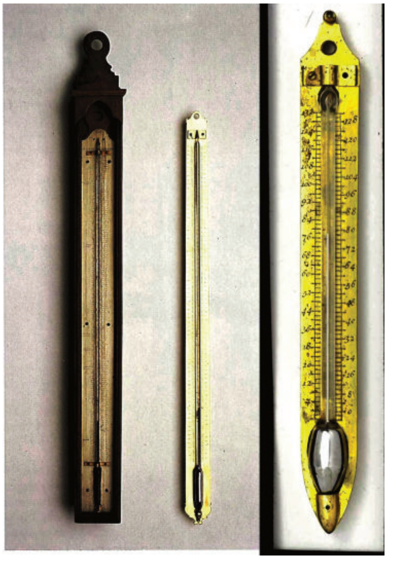


Figure 39. Fahrenheit's thermometers in Leiden (two on the left, photo by Januszajtis A.) and in private possession (one on the right)

It should be added that the Fahrenheit thermometers showing the same reading, which were admired by Chrystian Wolf in 1714 in Leipzig, had vessels 3.7 and 4.2 cm long and 0.66 and 0.5 cm in diameter. The scale length was the same - 17.4 cm. Later thermometers, preserved in Leiden, are much longer [Fig. 40]. It was unusual for Fahrenheit's contemporaries that two thermometers, placed in a vessel filled with hot water, would show the same temperature! Fahrenheit achieved true mastery in building thermometers. When he attended a meeting of the Royal Society of London for the first time on 5 March 1723, he showed something that would still be difficult to achieve even today: two thermometers - alcohol and mercury - with one scale!

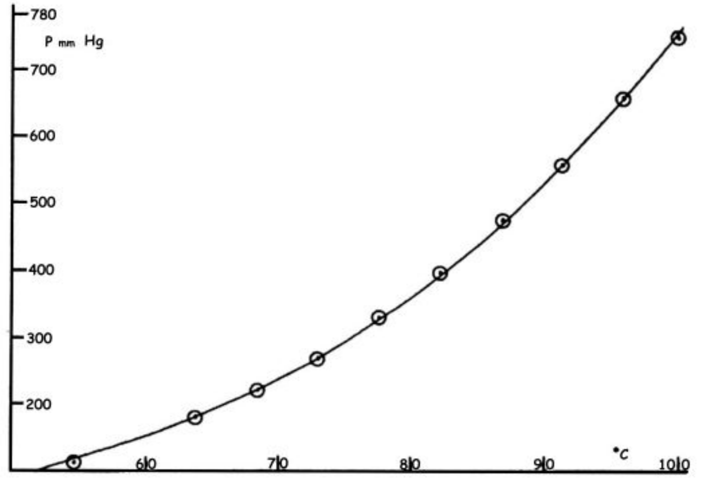
FIXED POINTS. The lecture notes of 1718 show that Fahrenheit marked his thermometers with accurately reproducible temperature standards. The lowest temperature, corresponding to zero on the scale, was obtained with a mixture of water, ice and salt. We do not know exactly today what kind of salt it was, because he referred to it once as sea salt, another time as ammonium chloride. Zero on his scale corresponds to -17.8°C. He chose the composition of the mixture himself - probably during his first stay in Amsterdam - and kept it secret.

The temperature of the water and ice mixture, i.e. the melting point of ice, was in those times reproducible only in winter (unless one had a cellar with supplies of ice). The melting point of ice on the Fahrenheit scale corresponded to 32°. It was much easier to achieve the "blood temperature" point adopted after Rømer, i.e. the body temperature of a healthy human being (36.6°C today) - it was sufficient to hold the thermometer bulb in the mouth or in the armpit. This temperature corresponded to 96° on the Fahrenheit scale (and 98° on a scale corrected later). As can be seen, our scientist considered it as uncertain. In one of his later letters to his protector, Herman Boerhaave, he wrote: “I have always considered the 96th degree (which, as you know, is the temperature of blood on my thermometer) as a fixed point for healthy people, but experience has taught me that children’s blood is hotter than that of older people, when I put a mercury thermometer in the mouths of children aged 8 to 10, the mercury rose 2 degrees higher than in my mouth. Therefore, there is no much more fixed point than that for crushed ice the gaps of which are filled with fresh water, or that for boiling water, as long as the air pressure is taken into account, and then it is always possible to mathematically get the 96th degree, just as I do it.“

Thus, we see that Fahrenheit did not consider the temperature of the human body to be constant enough to be used to gauge thermometers. On the other hand, it was possible to use the water boiling point mentioned here only after he had invented the mercury thermometer. It was not possible to measure the water boiling point with the previously used alcohol thermometers, because ethyl alcohol with which they were filled boils already at 80°C – while mercury only at 357°C. Fahrenheit started to fill his thermometers with mercury in Berlin in 1713. He also could not, as some argue, use his wife’s body temperature to gauge the thermometers for a very simple reason: he had no wife. He spent his entire adult life single.

OTHER DISCOVERIES. Another great achievement of Fahrenheit of fundamental importance before 1723 was the discovery of the dependence of the boiling point of liquid on the atmospheric pressure. He was the first to measure the pressure of saturated water vapour depending on pressure. It was an astonishingly accurate measurement: Fahrenheit’s measurement points are located practically without any deviations on the theoretical Clausius-Clapeyron curve more than a hundred years later [Fig. 41]. Let us listen to his own words: “In the report on my experiments with the boiling point of certain liquids, I mentioned that the boiling point of water at that time did not exceed 212 degrees; later I found in various studies and experiments that this point was sufficiently constant for the same weight of the atmosphere, but that it could change in different ways with a varying weight of the atmosphere (the term “the weight of the atmosphere“ should be understood as the atmospheric pressure). And here is how he explained this relation: “Water does not always boil to the same degree of heat as Mr. Amontons and others, including myself, have always thought. But it boils at a higher degree of heat in a heavier atmosphere (higher atmospheric pressure) and at a lower degree in a lighter atmosphere; thus, the boiling point of water always depends on the weight of the atmosphere, because water molecules, more or less compressed, need stronger shaking to separate from one another and become vapour. The word “shaking“ is defined by Fahrenheit elsewhere as “transmission of vibrations“ (today we would say: energy).

And here is how explained the liquid boiling process: “There are two things to consider with this boiling issue; first - the effect that fire (heat)



Ciśnienie pary wodnej nasyconej w funkcji temperatury: punkty pomiarowe Fahrenheita (wg unormowanej skali) i współczesna krzywa (*P. v. d. Starr*)

Figure 40. Saturated vapour pressure as a function of temperature: Fahrenheit's measurement points (according to a standardized scale) and a modern curve (Starr)

has on and towards liquid particles, and second – the counteraction of liquid particles with which they respond to fire and resist. And as far as the action of fire is concerned, it consists mainly in the fact that violently moving particles of fire transmit their movements (...) in the liquid to particles which are in this way gradually set in motion, and thus affect the particles of the liquid, shake them and make them vibrate, so that finally, by strong movements, the bonds that the liquid molecules hold between one another break, whereby they run away from each other and turn into vapour, and by permanent separation of these vapours the boiling liquid gradually disappears and finally seems to disappear completely.“ Further, the scientist describes how he increased the boiling point from 208 to 232 degrees on his scale by adding sea salt to water, and he also explains it on the basis of the molecular theory.

Fahrenheit was also a pioneer in low-temperature physics: in 1729 he developed a cascade cooling method that allowed him to lower the temperature of the liquid down to -40°. His other achievements worth mentioning include the extremely accurate measurements of thermal expansion of liquids and solids, measurements of the boiling point, measurement of the density of various substances with the hydrometer improved by him, discovering (independently from Israel Conradt, a Gdańsk physician) and explaining the phenomenon of liquid supercooling, methods of calculating the final temperature of liquid mixtures at different temperatures (calorimetric equation), the first description in the world of the transformation of the state of concentration of solutions and the eutectic point (the lowest melting point for a solution of a given composition), the first description of the properties of platinum, etc. His other inventions included medical thermometers, which would sell for a florin apiece, and a centrifugal pump for cleaning channels, for which he obtained a patent just before his death. A perfect model of the eye made by him can be seen in the museum in Groningen.

Daniel Gabriel Fahrenheit was a true pioneer in many fields of physics. If the Nobel Prize had been awarded in his day, he would have certainly received it.

APPARATUS IN THE HOUSE. After Fahrenheit's death, an inventory of all items in his apartment in Amsterdam was taken. The apparatus was more interesting than the furniture but it was underestimated by the inventory takers who did not see its value. Several flasks and glass vessels, a small mortar, glass tubes for instruments and cases for barometers were found in a "painted chest of drawers" in the front room. In addition to the chest of drawers, a "glass clock", which was probably a mercury hourglass, once proposed by Fahrenheit as a navigation chronometer, more tubes and capillaries, four old prisms and several boxes with copper and iron rings, and "more junk" were also found. Much more was taken down in the inventory in the back room: "16 smooth plates for thermometers, several mechanical devices", and in the chest of drawers "an air pump and various instruments, including optical and hydrostatic devices and several minor items, 2 small balls, iron weights, 2 water containers with copper taps (...), a drawer with tools such as a hammer, pincers, drills, etc., a drawer with some glass tubes for barometers and a chimney gate, a thermometer belonging to Mr. Heshuizen of Haarlem, *ditto* (*ditto* = as above, in this case it is about a second thermometer – the author's note) belonging to Mr. Buck, a coin master from Dort, and one (*ditto*) belonging to Mr. Hendrik de Raad (...) and 1 plate belonging to Vos, the apothecary at Herenstraat." The above mentioned table with bellows found in the hallway was also someone else's property; it belonged to a Costerus, probably one of Fahrenheit's clients.

Let us have a look at the book collection in the office. *Travels on Sea and Land* in 28 parts *in octavo* (small format), a Willem Seewels Dictionary, a two-part van Halma Dictionary, eight bound foliants, 11 d^0 *in quarto* (normal format)" and several other "bound and unbound books *in octavo* (small format) and *duodecimo* (miniature format) "and several "unbound ones *in quarto*", and last but not least, the *Great Book of Mills* (probably windmills) in two parts. The modesty of the book collection must have resulted from the significant deterioration of Fahrenheit's financial situation in the last period of his life.

FAHRENHEIT AS A LECTURER. Daniel Gabriel's share of his parents' estate was quickly expedited on expensive apparatus, materials required to conduct experiments, and books. To make ends meet, Fahrenheit delivered paid lectures for amateurs in 1718-1729. Notes from the first series of these lectures taken down by Ploos van Amstel who attended them have been preserved. Their history was extraordinary. The author gave them to his son, who made clean copies of them. The manuscript later came to Professor Jan Hendrik van Swinden (1746-1823), the author of *A Dissertation on Thermometers Comparatively Considered* (*Dissertation sur la comparaison des thermometres*) published in 1792. In 1866 the notes were put up at an auction in Amsterdam, where they were purchased by the Library of the University of Leiden for one gulden (!).The manuscript illustrated with numerous drawings is an invaluable source to learn the content and methodology of the scientist's lectures. Comparing them with later advertising brochures and letters, it is possible to trace the evolution and continuous perfection of Fahrenheit's teaching methodology. Like every conscientious lecturer, he would deepen his knowledge while preparing himself for lectures. An extremely important role in those lectures was played by demonstration experiments. Here is, for instance, a description of the measurement of atmospheric pressure at the tower of the Western Church (Westerkerk) at the Ducal Canal in Amsterdam using a mercury barometer, as noted by a listener:

"An experiment with a barometer performed on the Westerkerk tower, which shows that air molecules, like all liquid bodies, gravitate towards each other in a straight line.

Experience teaches us that all bodies, both liquid and solid, are heavy, but it is not so obvious that liquids also gravitate towards one another in a straight line and press against one another. But since the gravity of the air has also been demonstrated here before, it is also likely that the air molecules also gravitate towards one another in a straight line or press against one another as well. Many (scientists) have proved it in many places indeed. Nevertheless, we are supposed to go there to have the pleasure of observing it with a double barometer on the West Tower.

At the base of the tower, we found that the barometer indicated 28 inches 11 1/2 lines and the thermometer showed 69 degrees.

In the first gallery the barometer showed 28 inches 9 3/4 lines, and the thermometer 68 degrees.

In the highest gallery the barometer showed 28 inches 8 5/8 lines, and the thermometer - 69 degrees.

So the barometer, counting from the base of the tower to the highest level, showed (a difference) of 2 1/8 lines.

These observations clearly prove the theorem that the molecules of all fluids and air press against each other in a straight line, because a change in the mercury level, which at the height of the tower was the lowest, is caused only by the lower pressure of the air molecules felt by the mercury surface whereby the atmosphere was pressing weaker as much as was at the highest level of the tower; and when we had come back to the base of the tower, the atmosphere or the pressure of the air molecules again became much greater than at the top of the tower; which must have been the reason why the mercury in the barometer went up again to 28 inches 11 1/2 lines. To get a clear picture, it should be said (...) that the mercury level in the barometer is maintained solely by the pressure of the atmospheric air molecules and maintains a permanent equilibrium with them".

During the next lesson, the students learned how to measure the height of the tower with a barometer. "To do this, we need to accurately determine the weight of the air before going up the tower. Then we calculate how many times the air is lighter than mercury and this will show us how tall the tower is." Then listeners were given a sheet to fill with figures and make calculations. They found the height by multiplying the differences in the height of the mercury column in the barometer at the base and in the galleries of the tower by the relation of the density of mercury and air. The resulting height of the upper gallery of the tower was 68 m - two meters more than in reality. This slight deviation resulted from the fact that the air density assumed was a little bit too low. In the next lecture, the listeners measured its value.

The notes are accompanied by drawings, thanks to which we can learn about the demonstration instruments used by Fahrenheit. These included many interesting items which could serve even today, such as an ingenious device for demonstrating the refraction of light in water. The above given examples confirm the high methodological values of Fahrenheit's lectures and show what an excellent teacher he was. He had a clear picture of what he was talking about and he was able to convey it to his audience. Although he was accused of having no proficiency in higher mathematics which was necessary for university lectures it was not required for lectures given to amateurs.

MIRAGES. Even the most outstanding minds sometimes go astray. In 1715, Daniel Gabriel wasted a lot of time for such wanderings. We know about this from the letter of professor Christian Wolff to Gotfryd Leibniz: "Fahrenheit is in Leipzig. He wrote to me a few months ago reporting the great progress he had made in the construction of a perpetual motion machine, but that he was still looking for a way to overcome the equilibrium so that the machine could be stopped. He also wrote that if I was willing to investigate the problem and overcome the deficiency, he would come to me and bring his machine. I replied that overcoming the defect would practically be tantamount to developing an entirely new plan and that I very much doubted a successful outcome. (...) It is admirable that he has so far put so much effort into constructing thermometers and barometers, but has so little experience in mathematics that any discoveries he will make will come rather from chance than understanding." We should not be surprised that the then young Fahrenheit fell under the delusion of constructing a perpetual motion machine, about which already Leonardo da Vinci had known that it could not be built, and which was convincingly justified by Simon Stevin in 1586. It was as late as in 1775 that the Paris Academy announced that it would not consider nonsensical projects, with which, by the way, patent offices have been flooded to this day.

Much more interesting, though hardly realistic, was another idea, on which Fahrenheit was also working at that time: "a machine by means of which (...) it will be possible to obtain the longitude at sea" [Fig. 42]. It was supposed to consist of "two cylinders linked by a curved tube, one of which is constantly filled with mercury while the other is empty; at the bottom (...), in the bend, the tube is equipped with a very small opening through which mercury has to press itself from one cylinder to the other. The machine is attached to a board or a metal plate which in turn is attached to another board, but so that the former can be moved from left to right and backwards and then reattached. This displacement serves to place the cylinder with mercury higher than the other one so that the mercury, when half of its amount has flowed out, does not stop altogether, so it must reach as far at the point of equilibrium. (...) As soon as mercury reaches it, the instrument turns as quickly as possible so that the mercury should flow from the full cylinder to the empty one again. This machine measures the time very accurately." Fahrenheit goes on to encourage to have two such mercury hourglasses on board a ship, one set for 24 hours and the other for a week and estimates the error as one minute, or ¼ degrees of the longitude, and argues a bit naively that the rocking of the ship will have no effect because the "clock" is hanging vertically all the time. The impulse that prompted him to address this subject was the great prize announced by the just established British Admiralty (in 1714).

Wilhelm Leibniz to whom he sent this description advised him in his reply "to investigate the matter more closely because the committee, established by the British Parliament, wants to have not only ideas but ready made objects." He then added several critical comments which made Fahrenheit discontinue further work on the invention.

POLE OR GERMAN?. Earlier encyclopaedias, including Polish editions, usually described Fahrenheit as a German scientist. According to the latest edition of the British Encyclopaedia, he was: a "Polish-born Dutch physicist"(!). What was the truth? Let us recall the most important facts. The Fahrenheit family came from Königsberg, where as early as in 1512 we meet the merchant Hans Fahrenheit, who arrived there from Rostock and came from Hildesheim. A direct descendant of the family's Königsberg branch was, among others, Fritz von Farenheid (1815-1888), spelling his name somewhat differently, the owner of the once famous painting gallery in Bejnuny (currently Czernyszewka) in East Prussia, whose descendants now live in Germany and in the Netherlands. Nonetheless, we are primarily interested in the Gdańsk branch. The first to move from Königsberg to Gdańsk was Daniel Gabriel's grandfather Reinhold Fahrenheit (b. 1617 – ob. 1677) who received the merchant citizenship in 1649. He married Anna Greverath of Gdańsk (1623-1677). Their son Daniel (1656-1701), a wealthy merchant and shipowner, the father of our scientist, married the widow Concordia Runge (1657-1701), daughter of Michael Schumann (1624-1673) and Elizabeth Dassau (1632-1663). Until now, we have been moving in a circle of undoubtedly German burghers. Nevertheless, this does not justify calling Fahrenheit a German scientist in the understanding of today. In his time, Gdańsk did not belong to Germany, but to the Polish Crown (i.e. the Kingdom of Poland). Its inhabitants were rightful citizens of the Polish Republic, having the same rights in every city as other burghers. Every citizen of Gdańsk, reaching the age of majority, wishing to practice a trade, swore to the then reigning king of Poland "to be faithful and obedient, to care for his honour", as well as "to foster and contribute to the common benefit and prosperity of the splendid Polish Crown and these Prussian lands". Their most close homeland was Gdańsk, greater - Royal Prussia, i.e. Polish (Polnisch-Preussen, or Königlich-Preussen Polnischen Anteils), the greatest - Poland. The great Gdańsk historian, Gotfryd Lengnich, teacher and tutor of Stanisław August, from 1718 started to publish his Polish Library (Polnische Bibliothek), devoted to the history of Poland, since he wanted to - as he wrote in the preface - " present the history of his Fatherland (*mein Vaterland*) in a true light".

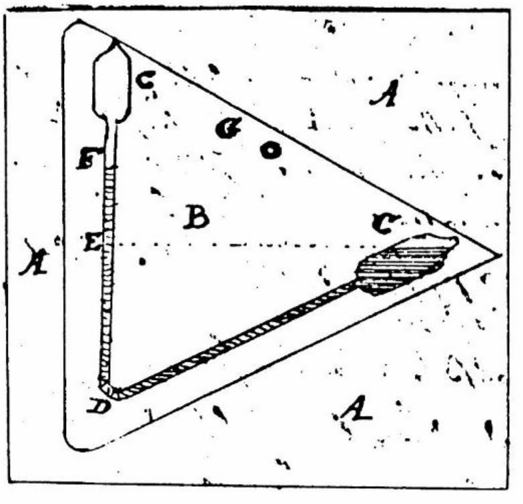


Figure 41. Fahrenheit's instrument for determining longitude at sea

What is the conclusion? As we have already explained in the case of Hevelius, Germans were in a majority in the pre-partition Gdańsk, however, they were Polish Germans, citizens of the Kingdom of Poland. It is not possible, in today's sense of the word, to classify Gdańsk as a German city, and its inhabitants as German. In the period of more than a thousand years of its history, for 146 years Gdańsk was in the state of the Teutonic Knights, for 126 years in Germany, and for 26 years it had the formal status of a Free City – which gives 298 years in total. For the whole remaining period (well more than 700 years) it was under the authority of the Polish rulers. During almost half of this period (in the years 1454-1793), it enjoyed the great freedoms granted by them. The attitude towards Poland was best described by the citizens of Gdańsk during the siege of the city by King Stefan Batory, who wanted them to pay tribute before he confirmed the city's privileges, but they preferred the reverse order. We have already quoted the wording of the unusual oath made on the ramparts facing the besieging royal troops. The eternal annexing and union (uhralde Einvorleibung und Voreinigung) with the Polish Crown of old, and by no means a "Free City in a personal union with the Polish Republic", as some have tried to interpret it until today.

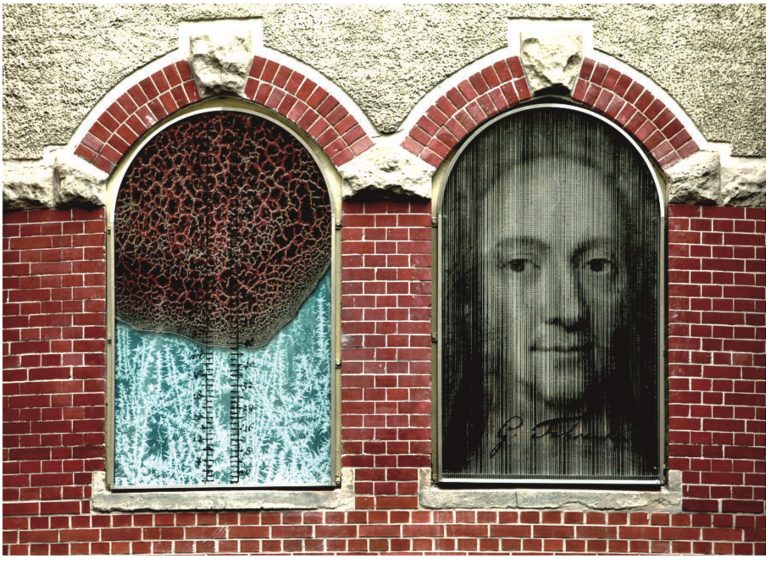


Figure 42. Fahrenheit in the courtyard in the Main Building of the Gdańsk University of Technology named after him

Similarly to Hevelius, Fahrenheit is the patron of the second courtyard of the Main Building of the Gdańsk University of Technology covered with a glass roof, decorated in 2012 with appropriate artistic works, including an electronically generated portrait using innovative methods [Fig. 43]. Nevertheless, the source data was insufficient to treat the portrait as a real image of the scientist. It may only be said that we would have nothing against him looking like this.

Daniel Gralath. Daniel Gralath (Senior) was a son of a wealthy Gdańsk merchant, Carl Ludwig Gralath of Regensburg, and Concordia Grentz of Gdańsk, a goldsmith's daughter [Fig. 44]. The future scientist was born on 30 May 1708 in the Old Town, where his parents had lived, before they moved to the Main Town to a tenement house on 40 Długa Street. Already at the Academic Gymnasium, where he studied under the famous naturalist Johann Adam Kulm, he revealed his outstanding talents and interest in exact sciences. It was also here (in 1729) where his three earliest dissertations were written: *On Water Meteors, On the Origin of Springs, and On Magnetism.* Having studied law and philosophy in Halle, Leiden and Marburg, where he attended lectures delivered by the famous Christian Wolff, he made a short trip to France. Having returned to Gdańsk in 1734, he married Dorothea Julianna, daughter of the eminent naturalist Jacob Theodor Klein, and entered the service in the municipal administration. In 1738 he became a social welfare inspector. In 1742 (and not in 1743, as is usually assumed) he founded the famous Society of Experimental Physics (*Societas Physicae Experimentalis*), better known as the Natural Science Society (*Naturforschende Gesellschaft*), which was the first natural science society in Poland and the second physical society in the world (see below). He also did not neglect the municipal affairs: from 1748 he was the head quartermaster (chairman) of the High Quarter in the Third Order, as early as in 1754 he was a juror, in 1758 a councillor, and the mayor from 1763, one of the last in Gdańsk before the partitions of Poland. During the Seven Years' War, he showed his diplomatic talent, persuading the commander of the Russian army to resign from entering Gdańsk. He died on 23 July 1767. On his deathbed, he founded a beautiful four-row linden avenue, known today as Aleja Zwycięstwa (Victory Avenue). It is also there, at the end of Smoluchowskiego Street, where his monument in the form of a modest erratic boulder with a plaque in two languages restored in 2000 has been standing since 1900 [Fig. 45].

Figure 43. Daniel Gralath, family collection, Gdańsk National Museum (Photo: Januszajtis A.)

Gralath was most interested in electrostatics. As any diligent scientist, he had preceded his research with a thorough study of the literature. His notes served later to create the three-part *Electricity Chronicles* (1747, 1754, 1756) - the first in the world, and the two volume *Electrical Library* (1754, 1756). Both studies have not lost their value until today. After such preparation, Gralath began his research work.

He started with simple experiments with a prototype of Winkler's electrostatic machine. His objective was to obtain the longest possible electric sparks to set fire to spirit, a wick of a freshly blown candle, he would kill small animals and cause electric shocks to people. However, it is his experiments with the so-called Leyden jar that are of the greatest value [Fig. 46]. The name is in fact incorrect as it had been invented by the prelate of the Chapter in Kamień Pomorski (Cammin in Pommerania), Ewald Jürgen von Kleist in 1745, many months before Pieter Musschenbroek began his experiments in Leiden. Kleist sent a letter

Figure 44. Monument to Daniel Gralath in the Avenue founded by him (Photo: Januszajtis A.)

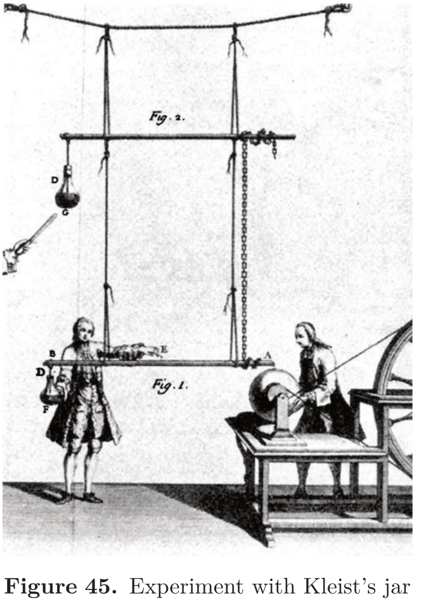


Figure 45. Experiment with Kleist's jar

advising about the discovery to Paweł Świetlicki, deacon of St. John's Church, member of the Gdańsk Natural Society who made Gralath interested in the new instrument. Due to problems which Kleist could not explain, Gralath succeeded with the experiment with the jar as late as on 5 March 1746 only. Musschenbroek was also successful at the same time, and the French Academy of Sciences which was informed thereof in the middle of the year, gave the first electric capacitor the name of the Leyden jar. The protests were to no avail. Although abbot Nollet, whose authority played an important role in this matter, admitted in a letter that if the jar had not been called Leyden, it would have been given the Gdańsk one but, it was where it ended. Gralath himself always modestly called it the Kleist jar.

Gralath's undisputed achievement was the setting of batteries of these prototypes of capacitors in the same year: "So I set up the experiment in such a way that two or three people were holding the tin pipe of the amplifying machine with one hand, I gave each of them a special iron or brass wire to hold in the other hand: the other end of the wire was taken in the left hand by another person who did not hold a vial, and the right hand finger was coming closer to the charged tube, so that the expected amplification should show itself as clearly as possible. When I set up the experiment with two vials in this way, although there were sparks and shocks coming from them felt by the person whose finger was approaching the tin pipe, definitely stronger than those in the experiment with one vial, they were still bearable; however, when I took three vials, there were few who would endure it more than once, as the shocks were powerful and painful. At the same time, it should be noted that other persons who were holding the vials felt as if they were holding one vial only". We should not be laughing at this reference to human sensations as a measure of the effect! Voltmeters did not exist at that time. These phials (Kleist jars) were connected by Gralath in series using people holding them together with wires.

BEFORE COULOMB Gralath was also one of the first researchers to try to quantify the interaction between charged bodies. For this purpose, in the same fruitful year of 1746, he used a precise scale designed by another member of the Natural Science Society, the mathematician Henryk Kühn, about whom we write elsewhere. Gralath placed the end of a metal rod, charged by a glass ball, under the pan of an earthed scale. The force of attraction between the rod and the pan was balanced by weights placed on the other scale pan. The distance between the rod and the pan was changed by adjusting the screws of the stand on which the rod was placed. He also took into account the distance of the glass ball from the rod connected thereto with a brass wire. Here are the results obtained by him:

Table 1. Results of Gralath's measurements of electrostatic force

Distance from the ball	The attraction force in grans for the distance between the pan and the rod surface			
	3 in.	2 in.	1 in.	½ in.
240 feet	1½	4	13¾	44
80 feet	2½	7¼	20¾	70½
10 feet	3½	8¼	26	74

And then, instead of properly interpreting his measurements, Gralath is making intricate reflections about the relationship between the strength of the electrical attraction and the length of the spark! Had he repeated the same experiment with a more favourable geometry, e.g. with two spherical electrodes, he would have doubtlessly arrived at the so-called Coulomb's law formulated 14 years later by Daniel Bernoulli (perhaps after he had read Gralath's work?). I am writing "so-called" because Augustin Coulomb "discovered" it, after much more precise, carefully conducted measurements, as late as in 1785. In any case, Gralath's measurements were the first in the world to use an electroscopic scale.

SONS AND DAUGHTER. The scientist's three sons also deserve attention. The eldest, Theodor Ludwig (1738-1761) left a dissertation on the benefits of science, read on the 200th anniversary of the establishment of the Academic Gymnasium in 1758. His promising career was interrupted by premature death. The second son, Daniel Gralath Junior (1739-1809) was an outstanding historian, professor from 1764, and rector of the Gdańsk University from 1799. The youngest of the sons, Carl Friedrich (1741-1818), after his studies and travels, which he described in an interesting journal, was successively a City Council secretary, juror, councillor and - from 1794 - the Mayor of Gdańsk. In the years 1768-1775 he was a Gdańsk resident (representative) in Warsaw. The godfather of his son, Stanisław Karol, was King Stanisław August Poniatowski.

The daughter of Daniel Gralath the Elder, Renate Wilhelmine (1748-1808), also had a scientific flair [Fig. 47]. A friend of Duchess Anna Jabłonowska, in 1778 she helped her organize the famous naturalist collection in Siemiatycze and for two years she looked after a part of the collection in Gdańsk. Let us quote a fragment of her letter to the astronomer Johann Bernoulli dated 29 September 1778, which proves her considerable knowledge in this field:

"The duchess's cabinet deserves the attention of an expert. The Duchess spares neither efforts nor money to complete it, last year numerous boxes containing various natural curiosities for the collection were shipped to her from the Netherlands. The exhibits sent this year which were to complete the collection in the cabinet, are still with me; our library looks more like a museum when I decorated it with over 180 jars containing quadrupeds, fish, snakes, etc. - preserved in spirit. Moreover, birds from foreign countries and stuffed monkeys, shells, where the most valuable specimens are *Pavillon d'orange* and *Natile papirace* ... As far as the collection of shells is concerned, I must confess that I arranged it myself by families according to the combined system of Messrs. d'Argebville and Daville. While the duchess was travelling around Poland, I had the honour of look after her collections in Gdańsk, which I supervised for two and a half years. This evidence of the Duchess' trust flatters me very much."

Here is what she wrote in her second letter dated 30 April 1779 notifying Bernoulli of another lot of purchased specimens:

"I expect three volumes of your letters on various topics from Nicola to be able to send them to Duchess Jabłonowska. I will also send her a volume with

Figure 46. Portrait of Renate Wilhelmine Gralath, family collection, National Museum of Gdańsk (Photo: Januszajtis A.)

accounts of your recent travels as soon as they appear in print. I have recently received a message that the ship, currently on its way, is carrying a significant number of live birds for the Duchess. This Noah's Ark will arrive in two weeks at the latest. There will be specimens from four parts of the world: ducks and geese from India, roosters and hens from Africa, pigeons from Ceylon. The Dutch gentlemen use the Duchess's permission and send interesting specimens. 200 various birds in total are supposed to arrive, which, according to the bill, will cost 800 Dutch florins. The poultry is quite expensive indeed!"

Unable to accept the Duchess's decision to abandon further collection of specimen that were eventually purchased by Tsar Alexander I, Renate Wilhelmine returned to Gdańsk. In 1790, she married the mayor Eduard Friedrich von Conradi, who was 35 years her senior. After his death in 1800, she remarried the Prussian minister, Baron Frederick Leopold von Schrötter, under whose supervision the most accurate map of Royal Prussia at that time was drawn.

Heinrich Kühn. A characteristic feature of the culture of the old Gdańsk, including science, was its opening to the world. The ties between the Gdańsk community and Königsberg and its university - the famous "Albertine" were particularly close. The activity of Heinrich Kühn can serve as an example. Born in Königsberg on 19 November 1690, he studied there from 1707, and afterwards moved to Halle, where he received his Ph.D. degree in law. However, this did not satisfy his hunger for knowledge and in 1717 he re-enrolled at the University of Königsberg, this time devoting himself to natural sciences. In 1733, he moved to Gdańsk, where he was appointed professor of mathematics at the Academic Gymnasium. The compensation was not high, so on the basis of a special royal privilege, professors of mathematics had the right to issue calendars. Kühn's calendars, issued in the years 1735-1770, were distinct for their logical layout, high level of information and interesting contents. For example, the calendar of 1746 - with a huge eagle on the cover - contains, in addition to astronomical data and historical dates, proverbs, epigrams, a description of sugar production methods, a list of fairs in Poland and Germany, and ... a story about a thief in love.

Kühn was a co-founder of the Natural Science Society established at the turn of 1742 and 1743 and he joined its operation from the very start. It is already in the first volume of *Experiments and Dissertations of the Natural Science Society* (*Versuche und Abhandlungen der Naturforschenden Gesellschaft*) published by the Society since 1747 that we can find five of his dissertations. The first: A detailed description of a new and improved type of a scale ... has a lasting value. In addition to the elementary knowledge in the field of statics, it includes the theory of scales and weighing, and a very valuable description of the scale, constructed in 1743 according to Kühn's guidelines by the travelling mechanic Drunckmüller. As the author was claiming, the scale could be used to weigh "not only equal but also unequal weights (...) precisely with respect to each other, or divide a given weight into smaller ones in any proportion". The original design with shock-absorbing friction wheels and a high sensitivity and accuracy of indications allow Kühn's scale to be considered a successful prototype of later analytical scales [Fig. 48].

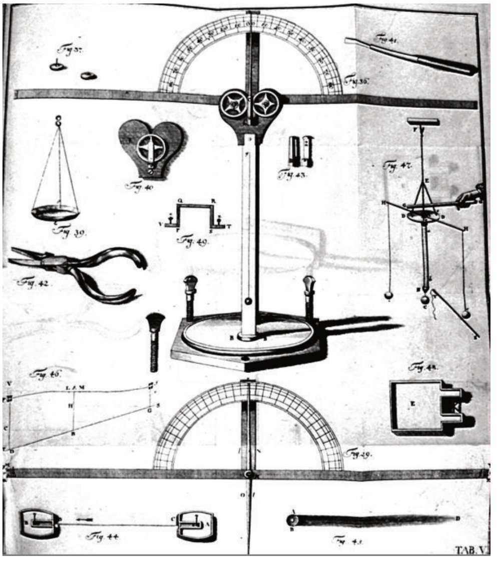


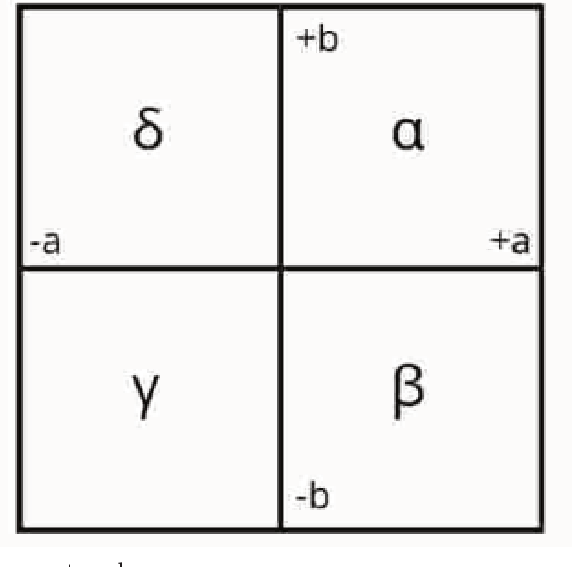
Figure 47. Kühn-Gralath electrostatic scale

The latter dissertation includes a design of ingenious apparatus based on the principle of communicating vessels to be used for measuring the fall of water in rivers; the third work concerns sunspots; the fourth - comet tails;

the fifth contains ideas about the density and clarity of air. Also the third volume of *Experiments and Discourses* of 1756 contains an article by Kühn attempting to explain the causes of ocean tides.

The most prominent work by Kühn, ensuring him a permanent place in the history of science, are *Considerations on Constructing Imaginary Quantities and Extracting Imaginary Roots* from 1750-1751, published in 1756 in the third volume of *New Commentaries of the Petersburg Academy of Sciences*. It was the first attempt at geometric interpretation of complex numbers in the history of mathematics. This dissertation made the Gdańsk scientist internationally famous, and the St. Petersburg Academy of Sciences accepted him as a member.

As a starting point Kühn took rectangles α, β, γ and δ, touching with sides formed on the axes of the coordinate system:



The areas of these rectangles are:

$$S_\alpha = +ab, \quad S_\beta = -ba, \quad S_\gamma = +ba, \quad S_\delta = -ab.$$

If the sides of the rectangles are equal with each other, e.g. $a = b = 3$, then:

$$S_\alpha = S_\gamma = 9 \quad \text{and} \quad S_\beta = S_\delta = -9$$

and their lengths can be represented as: $\pm\sqrt{9}$ and $\pm\sqrt{-9}$.

Kühn continues as follows: "It should not be claimed that such a quantity as $\pm\sqrt{-9}$ is only imaginary, impossible and unacceptable, as that there is no way to extract the square root from $-a2$, since both $(+a)\cdot(+a) = +a^2$, and $(-a)\cdot(-a) = +a^2$ for the calculus which is derived from possible, i.e. real, given numbers and was made in accordance with the unquestionable rules, could in no way lead to something impossible, unreal, unacceptable, and on the other hand, the prescribed construction makes it possible for us to see that the assumption that all real squares should be positive is not true".

It is known that the currently used interpretation of complex numbers as points on a plane was proposed in 1799 by the Norwegian Caspar Wessel, and immediately afterwards and independently by Jean Robert Argand and Charles Frederick Gauss.

The membership in the Russian Academy of Sciences was not the first proof of recognition of Kühn abroad. As early as in 1741, the Scientific Society of Bordeaux awarded his work, *Considerations on the Origin of Sources*, published five years later in two versions - Latin and French.

Kühn's last known publications were: the famous lecture delivered on the occasion of the 200$^{\text{th}}$ anniversary of the Academic Gymnasium in 1758 *On the Influence of Mathematical and Natural Sciences on the Temporal Happiness of Mankind* and published posthumously in 1771 which was an attempt to strictly solve certain cubic equations.

Henryk Kühn died in Gdańsk on 8 October 1769. He had a daughter with his wife Julianna Carolina (1701-1793) whose name is unknown and who was buried in 1739 - probably in early childhood. There is no news about other family members. After a long period of oblivion, it was only nineteenth-century historians of mathematics that appreciated Kühn's achievements whereby he can be considered as one of the most outstanding scientists of the 18$^{\text{th}}centuryinQQPoland$.

Other eighteenth-century Gdańsk scientists recognized worldwide to be mentioned include the botanist **Jacob Theodor Klein** (1685-1759) who developed zoological systematics independent of Linnaeus. The honorary member of the Society **Johann Reinhold Forster** (1729-1798) was the scientific director of Cook's second expedition, and his son **Johann George Forster** (1754-1794), professor at the University of Vilnius who presented the theory of the evolution of species more than 70 years before Darwin. All these individuals are described in more detail in the chapter on the Gdańsk members of the Royal Society of London (pp. 84 ff.)

Arthur Schopenhauer. The greatest fame among the Gdańsk scientists of old is enjoyed by the great philosopher Arthur Schopenhauer (1788-1860) [Fig. 49]. Although he spent most of his life out of Gdańsk, he still maintained ties with his hometown. When somebody said he was German, he would reply: "I am not a German, but a citizen of Gdańsk of Dutch origin" (his grandmother Renata Soermans was the daughter of a Dutch consul). His outlook on life, most fully expressed in his fundamental work *The World as Will and Representation*, enjoyed greatest triumphs - also in Poland - at the turn of the 19$^{\text{th}}$ and 20$^{\text{th}}$ centuries. Let us recall some dates from his life: Born on 22 February 1788 in Gdańsk, son of Heinrich Floris Schopenhauer and Johanna Joanna Schopenhauer née Trosiner, he spent five years of carefree childhood here. In 1793, on the eve of the second partition of Poland, in which the Prussian king seized Gdańsk, his parents moved to Hamburg. Arthur later explained the reason for the departure in the following way: "My father, who loved both freedom and his homeland, could not come to terms with the fall of the old republic." In the years 1797-1799 the young man stayed with his father's friends in Le Havre, where - to his joy - he almost forgot to speak German. Having returned, he learns the merchant trade, but misses his studies. He makes a grand journey with his family across England, France, Switzerland and Austria that changes his outlook for life: "In the 17th year of my life, without any learned school knowledge, I was struck by the misery of life, like the Buddha in his youth, when he saw sickness, old age, pain and death. Having retuned and after his father's death, he interrupts his work in the office and, thanks to to his mother, begins to study in Gotha and Weimar in 1807. He masters seven languages. There are disagreements with his mother, who thinks that he is trying to be too smart. In 1809, he enrols to study medicine, and in 1810, philosophy in Göttingen. In the years 1811-1813 he studies in Berlin and then graduates in Jena. In 1814, he breaks contacts with his mother and moves to Dresden. In 1818 he completes his most important work *The World as Will and Representation.* In 1819 he travels across Italy, where he creates a scandal in a local German colony with his contemptuous statements about Germans. He himself writes about this period of his life in the following way: The twenties and the young thirties are for the intellect what May is for the trees, during which season only they put forth buds whose later development is the fruit, the observed world has already left its mark and thus consolidated the resource for all future individual thoughts." Having received the news of the bankruptcy of a Gdańsk company, in which he had invested 1/3 of his assets (his mother and sister almost everything), he travels to Gdańsk and successfully settles matters to his advantage. In 1820 he obtains his postdoctoral degree in Berlin and begins to deliver lectures on the essence of the world and the human mind. There are no listeners, because he ostentatiously sets the dates simultaneously with the lectures of the students' idol Georg Wilhelm Friedrich Hegel. In 1822, he bids farewell to Berlin and leaves for Italy again. In 1823, he loses his hearing in one ear. In 1825 he returns to Berlin, where he unsuccessfully tries to obtain reciprocity from several females. Following a scandal with a cleaning lady, whom he threw down the stairs in a tantrum and to whom he had to pay compensation, he leaves for Frankfurt am Main in 1831, for Mannheim - in 1832, and finally in 1833 he settles permanently in Frankfurt, where in 1835 he writes a dissertation on the will in nature, in 1837 the award-winning work on freedom of the will, and in 1839 another - on the foundations of morality. In 1843 he finishes the second volume of his most important work. In 1851 *Parerga and Paralipomena* are published, some of which are Aphorisms on the wisdom of life. In 1859, Elizabeth Ney sculpts a bust of the philosopher. On 21 September 1860, Schopenhauer dies of pneumonia.

Arthur Schopenhauer is considered to be a pessimist – is it right? Although he admits that "there is not much to be got anywhere in the world" and that "it is evil which generally has the upper hand, and folly that makes the most noise. Fate is cruel and mankind pitiable". However, he has a non-pessimistic recipe for this – high spirits: "In a world so arranged, a human being with a rich interior is like a bright, warm, cheerful room in a snowy, frosty Christmas

Figure 48. Arthur Schopenhauer in 1845

night". Can the author of the following words be considered a pessimist: "That we exist means we will always exist. You can't fall out of existence in the way you fall out of a speeding coach"? Or such: "It is certainly a very melancholy thing that all a man's faculties tend to waste away as he grows old, and at a rate that increases in rapidity: but still, this is a necessary, nay, a beneficial arrangement, as otherwise death, for which it is a preparation, would be too hard to bear." For a pessimist, he quite often gives encouragement with his statements.

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