“It is far better to grasp the Universe as it really is than to persist in delusion, however satisfying and reassuring.”

Carl Sagan (1934-1996)
– American astronomer, writer and popularizer of science

NOT THAT SKY / NIE TO NIEBO

The sky is nothing more than the blue colour of the atmospheric layer beyond which the interplanetary void extends. Just 100 km above the Earth's surface there lies a conventional boundary between its atmosphere and the outer space, whose magnitude is far beyond the grasp of our imagination. There are fewer and fewer places in the world where the view of the night sky remains unaffected by human activity. However, once we happen to find ourselves away from the city lights, we can feast our eyes on the stellar projection. It is an extraordinary spectacle, one which has fascinated humans since the dawn of time. The darkness of the celestial vault at night, illuminated by the glare of the moon and the billions of stars, is still a mysterious, impenetrable reality that fires the imagination.

The stars in the sky are the image of light travelling from the remote reaches of space at a speed of 300,000 km/s. In fact, the pageant above our heads shows events from the distant past that we get to witness with enormous delay. The light from the closest star (Proxima Centauri) takes more than four years to reach Earth. This means that if the star exploded in real time today, we would see the blast only in 2027. The events visible in the night sky are thus a bridge between the past, the present and the future.

Astronomy and the phenomenon of the starry sky are the starting point for the story presented in the exhibition. An exhibition which does not aspire to be a cosmic encyclopaedia. We would like it to inspire you to discover the universe and its mysteries, to engage in conversations and explore, as well as to kindle your interest in the natural and exact sciences. After all, so many extraordinary things relating to the cosmos are within reach—not by spaceship, but by bicycle or on foot.

“There is nothing in life to be feared, only to be understood.”

Maria Skłodowska-Curie (1867-1934)
– Polish-French experimental physicist and physical chemist,
two-time winner of the Nobel Prize in physics and chemistry

Our story begins in the Archives of the Astronomical Observatory Institute of the Adam Mickiewicz University in Poznań, where we came across a mysterious envelope with the inscription “Not that sky”. It contained an old glass plate on which a fragment of the night sky had been captured. Until 1993, such plates were still in use when carrying out astronomical observations at the Institute. In order for the telescope to expose the desired object, the astronomer had to know the object’s position in the sky, the location of the observatory, the local time as well as allow for corrections dictated by the characteristics of the apparatus. Relying on such data, one would do the calculations—using nothing more than pencil on paper—to determine how the telescope should be directed. Even minor miscalculation would focus it on a star field other than the intended area: the eponymous “not that sky”. Much the same would happen if an inaccurate time source was used, such as a watch running slow, for instance.

01 - Ajisai satellite

author of the work: Justyna Olszewska
technical support: Kacper Krzętowski, Jakub Tokarek

Descriptions of the artworks can be found on the blue pads.

02 - Moon

03 - AS FAR AS THE EYE CAN SEE

Astronomical discoveries have had a major impact on our understanding of the universe. They changed our view of reality, time and space. The first observations were made using the simplest instrument: the human eye. Based on such naked-eye observations, Greek astronomer and mathematician Ptolemy (c. 100-168) shaped the image of the universe at the time, having developed the geocentric theory. Observing the sky at night, he concluded that it undoubtedly orbits above his head, while Earth remains stationary and constitutes the strict centre. For a long time thereafter, the theory dominated the understanding of the principles governing the cosmos, representing the sum total of the knowledge of the ancient world. With the onset of the Middle Ages, it was the Christian vision of the universe—based on the Ptolemaic theory—which would hold sway over our notions of cosmos. Still, it came to be challenged later on, as it did not logically account for certain phenomena in the sky, such as the retrograde motion of planets. In 1543, Polish astronomer Nicolaus Copernicus (1473-1543), published a treatise entitled *On the Revolutions of the Celestial Spheres*, causing a scientific upheaval known as the "Copernican Revolution". His heliocentric theory stated that it was the Sun, not Earth, which constituted the centre of our system. This concept became the foundation of the current astronomical knowledge and fostered further development of science.

As the primary tool of observation, the human eye is responsible for numerous breakthroughs in astronomy. Those simple observations yielded the first sky catalogues which described the brightness and position of the stars, produced the six-degree star magnitude scale--which is still used today—and led to the discovery of the first variable stars. The introduction of the telescope was an extremely important step, enabling one to observe fainter astronomical objects. It was only in 1609 that Galileo Galilei (1564-1642), Italian physicist, astronomer and philosopher, became the first to look through a telescope of his own construction. Using a fairly simple device, he managed to glimpse fainter stars and expand the previous stellar magnitude scale. Another scholar who constructed instruments himself was Polish astronomer Jan Hevelius (1611-1687). In 1640, he founded an astronomical observatory in Gdańsk, which he equipped with his own hand-made clocks, telescopes, sextants and quadrants, among others. Gifted with outstanding engineering skills, he cut and polished the lenses for the telescopes himself.

The dynamic development of technology produced increasingly precise observational instruments. Research would be carried out on advanced telescopes, replacing the human eye with detectors that enabled permanent record of the image of the sky. The first consisted of glass plates covered with photosensitive emulsion; subsequently, traditional photographic methods gave way to photosensitive electronic matrices (CCD and CMOS). In the last few years, the sensitivity of the cameras has been driven close to absolute darkness, making it possible to capture even single photons.

The invention of digital matrices is undoubtedly humankind’s major achievement. In 1969, Canadian physicist Willard Sterling Boyle (1924-2011) and American physicist George E. Smith (b. 1930) constructed a CCD sensor using the photoelectric effect (whose explanation won Albert Einstein the Nobel Prize in 1921). The importance of the invention is evinced by the fact that both scientists were awarded the Nobel Prize in 2009, while the sensor they created revolutionized the modern world. Initially used only in laboratories, the converter is now used in astronomy, medicine, and numerous industries, as well as in cinematography and photography.

The 20th century not only brought advances in optical telescope technology, but also opened the door to space exploration. In 1990, the Hubble Space Telescope, named after the American astronomer Edwin Hubble (1889-1953), was placed in orbit. The telescope is a large space observatory which revolutionized astronomy, supplying scientists with crystal-clear images of the universe. Scientists have used the Hubble Telescope to observe the most distant stars and galaxies ever, as well as study the planets of our solar system, thus changing the understanding of the universe. Repeatedly modernized over the three decades in service, the Hubble telescope has made more than 1.5 million observations in the spectra of visible light, ultraviolet and near-infrared. Its successor and continuator is the James Webb Space Telescope (JWST), named after NASA's second administrator, James Edwin Webb (1906-1992). This telescope conducts observation in the infrared range, which enables it to "see" into the dust clouds that its predecessor was unable to penetrate. In 2021, JWST began its space journey, while the first images were presented to the public in July 2022. Its mission is to observe the first stars formed after the Big Bang, study the emergence and evolution of galaxies, and explore how stars and planetary systems come into being. It is the largest and most powerful telescope ever launched into space; thanks to its capabilities, we are likely to see what we cannot yet imagine.

DID YOU KNOW THAT...

5 min on foot (550 m) / 4 min by bike (900 m) from ZAMEK Culture Centre

The collection of the Library of the Poznań Society of Friends of Science includes the first edition of one of the most important books in the history of astronomy, *De revolutionibus orbium coelestium* (*On the Revolutions of the Celestial Spheres*) by Nicolaus Copernicus, published in Nuremberg in 1543. Only 12 copies of that edition are to be found in Poland, three of which are near ZAMEK Cultural Centre. The second is held at the Raczyński Library, and another at the Library of the Polish Academy of Sciences in Kórnik.

49 min on foot (3.8 km) / 14 min by bike (4 km) from ZAMEK Culture Centre

The Astronomical Observatory Institute of the Adam Mickiewicz University in Poznań houses a Zeiss refractor that is over 100 years old. The telescope was made by the Carl Zeiss company in Jena around 1909-1910. It is a classic refractor, equipped with a two-lens achromatic lens with a diameter of 200 mm and a focal length of 3,000 mm, placed on a parallactic "German" mount.

52 h on foot (255 km) / 13 h 38 min by bike (267 km) from the ZAMEK Culture Centre

Founded in Słupsk in 2008, Polish company ScopeDome is one of the world's leading manufacturers of fully automated observation domes. They are designed for individual customers as well as schools, centres for scientific research in astronomy and related sciences, as well as institutions which popularize the science of the universe.

04 - THE NIGHT OF SHOOTING STARS

The nightly spectacle of shooting stars we get to see every now and again is nothing more than the so-called meteor shower. Meteorites, on the other hand, are space rocks that fall to Earth every day. The largest such object found to date—the Hoba—comes from Africa; it is 3 metres long and weighs 60 tonnes. The study of iron meteorites provides new information about the structure of the Earth's interior. After all, its core consists of iron, just as meteorites. Unfortunately, the fact that it is inaccessible precludes direct research.

METEOROID - a fragment of rock moving in orbit around the Sun. To be considered a meteoroid, the fragment must be of natural origin and measure approximately 1 mm to 1 m.

METEOR - a light phenomenon that crosses the sky. It is left behind by a flying meteoroid which, on entering Earth's atmosphere, begins to burn up; it can occur on any planet and moon with a sufficiently dense atmosphere.

METEORITE - a meteoroid that has not burned up in the atmosphere and has reached Earth's surface in solid form. It is assumed that hundreds of pieces of these cosmic rocks land on Earth every day.

BOLID - a very bright meteor, reaching at least magnitude 4 on the brightness scale, which makes it brighter than Venus.

MICROMETEOROIDS - meteorites less than 1 mm in diameter; they are the main component of the cosmic matter falling to Earth. Roughly 9 tonnes reach Earth each day.

How can you recognize a real meteorite?
One of the characteristic properties of iron meteorites are patterns known as the Widmanstätten figures, which may be seen in the cross-section of the meteorites. Such structures do not occur on Earth; they are formed in nickel-iron alloys which undergo very slow cooling.

How do I find a meteorite quickly?
Meteorites are easiest to spot in the deserts and in Antarctica, because their black colour stands out against the background of sand and snow. Iron meteorites are the easiest to find, as they are much heavier than normal stones and usually covered with a coating of rust.

DID YOU KNOW THAT...

2 hours 16 min on foot (10.8 km) / 40 min by bike (11.2 km) from ZAMEK Culture Centre

The Morasko Nature Reserve in the northern part of Poznań is an area which consists of a complex of craters formed by the fall of the Morasko meteorite 5,000 years ago. It is one of the few sites of its kind in the world. In 2017, the largest meteorite in Eastern Europe known as “Kruszynka [Little Mite]”, was discovered there by Andrzej Owczarzak and Michał Nebelski, buried 2 metres below the surface. Weighing 271 kg, “Kruszynka” is just a fragment of the iron Morasko meteorite, which disintegrated in the atmosphere and fell to Earth in the area from extending Suchy Las, through Morasko, to Radojewo and Umultowo.

1 hour 40 min on foot (8 km) / 29 min by bike (8.9 km) from ZAMEK Cultural Centre

Displayed at the Earth Museum of the AMU Faculty of Geographical and Geological Sciences, you will find one of the largest specimens of the Morasko meteorite, the “MEMORSS” (MEteoryt MORasko Skirzewska Smuła). The fragment was discovered in autumn 2012 and, with a weight of 261 kg, it dethroned the 161 kg specimen found earlier. The finds are the largest Polish meteorites and may be seen at the museum. The institution’s collection also includes fragments of other meteorites, including stone and stone-iron ones. Another large specimen of the Morasko meteorite, weighing 34 kg, is also worth mentioning. It was found while one of the episodes of the Discovery Channel’s popular science show *Meteorite Men* was being shot there.

On 3 October 2021, at 11.35 pm, a meteorite struck Ruth Hamilton’s home in British Columbia. It fell through the roof straight into her bed, landing between two floral pillows right next to Ms Hamilton’s head. The meteorite weighed about 1 kg. The probability of a meteorite hitting our house is 1 in 100 billion.

On 9 October 1992, in Peekskill, New York, USA, a meteorite struck a red Chevrolet Malibu standing in the street. The speed of the hot meteorite, weighing 12.37 kg, was 264 km/h when it hit the car. Michelle Knapp, the owner of the vehicle, sold the specimen for $50,000, while the car fetched him another $25,000. The car and the meteorite have been displayed in many museums around the world. They are currently at the Macovich Collection of Meteorites in the United States.

In the summer of 2021, a meteorite fell in the Greater Poland area. The hunt for the space rock began with the recording of the flyby by the Czech Fireball Network. When the information about the flight trajectory had been published, the Polish Fireball Network and prospectors embarked on a search for the meteorite. The likely suspect was discovered near Antonin (Greater Poland). The authenticity of the obtained sample was confirmed by means of radioisotope tests conducted at the National Centre for Nuclear Research (NCBJ) in Świerk.

METEORITE SWARM

A phenomenon which occurs when Earth in its orbit encounters a dense swarm of particles and debris created by the disintegration of a comet. These particles seemingly fly out from a single point in the sky called the radiant. Swarms are named after the constellations in which the radiant is located. When the density of the swarm is very high, the phenomenon is called a meteor shower.

05 - Three…Two...One...LIFTOFF!

Modern rockets are the result of an amazing combination of human ingenuity, science and technology on the one hand and countless experiments on the other. It is unclear when the idea of a rocket first appeared in human history. Stories of early rocket-like devices are found in the historical records of many cultures. Filled with gunpowder, they were mainly used as fireworks or missiles. However, there is an ancient Chinese legend in which a rocket is used as a means of transport.

In the story, a Chinese official named Wan-Hu is said to have built a rocket-powered flying chair, helped by a number of assistants. Attached to the seat there were two large kites and forty-seven fiery arrows. Once the rockets ignited, the official disappeared in a puff of smoke. Very likely, if that event really took place, Wan-Hu and his chair were blown to pieces.

In 1687, English physicist Isaac Newton (1642-1727) laid the scientific foundations for the development of rocket science by advancing the three principles of dynamics which define the relationship between the forces acting on a body and the motion of that body. Among other things, those principles explain how rockets work and why they are capable of operating in the vacuum of space. They also had a practical impact on the development of rocket design, although the conceptions of how they would be used remained unchanged.

It was not until the early 20th century that a real breakthrough was made. Konstantin Tsiolkovsky (1857-1935), a Russian scientist of Polish descent, was one of the first to come forward with a realistic concept of space exploration using a rocket. His 1903 article entitled *Exploration of Outer Space by Means of Rocket Devices* included a structural sketch of a liquid-fuel rocket and outlined how a multi-stage rocket could achieve minimum orbital velocity. Tsiolkovsky's crucial contribution in that respect was a formula describing the relation between the speed of the craft and its mass, whose parameters change as the fuel is combusted during flight.

Almost simultaneously, practical experiments with a rocket were carried out by Robert H. Goddard (1882-1945), American designer and pioneer of rocket technology, who in 1919 published a paper entitled *A Method of Reaching Extreme Altitudes*. Goddard managed to build the first ever liquid-fuel rocket: a difficult task since fuel and oxygen tanks, turbines and combustion chambers were needed. Despite the obstacles, Goddard accomplished the first successful flight of the rocket on 16 March 1926. He continued to experiment for many years, while his rockets would become larger and fly higher. He also developed a gyroscopic flight control system and a payload chamber for scientific instruments. Also, his craft were equipped with parachute systems to safely recover rockets and equipment.

The third major pioneer of rocket technology and space exploration was Austrian-German physicist Hermann Oberth (1894-1989). His 1922 doctoral thesis on the construction and use of rockets was rejected by the

University of Heidelberg as “too fanciful”. In 1923, he published *By Rocket into Planetary Space*, a book on rocket-mediated travel into space, which included mathematical calculations of technical solutions. His scientific achievements contributed to the popularization of rocket technology and the establishment of many rocket associations. With the Nazi’s coming to power in Germany and the outbreak of the Second World War, interest in using rockets for military purposes considerably increased. The German scientific community became involved in the development of new rocket-propelled ordnance, the so-called *Wunderwaffe* or “wonder weapon”. Oberth was joined a young German engineer, Wernher von Braun (1912-1977). Their collaboration produced the V-2 rocket, which was the first to reach space during a test flight on 3 October 1942. Its main purpose, however, was to destroy cities in Britain, France and the Netherlands. Nearly 5,500 rockets were launched during the war. Following the fall of the Third Reich and the end of the war, the chief designers—including Wernher von Braun— were captured and recruited by the US, which also seized many unused V-2 rockets.

The post-war years were dominated by the rivalry between the US and the USSR, which vied for primacy in the space conquest and arms race, thus contributing to the development of space technology.

In October 1958, the United States officially launched its space exploration programme, creating the National Aeronautics and Space Administration (NASA). NASA became a civilian agency focused on the peaceful exploration of space for the benefit of all humankind. The first director of the George C. Marshall Space Flight Center in Alabama was Wernher von Braun, who headed the US space flight programme from 1966 to 1972. Its aim was to land man on the moon and then have them return safely to Earth. The task was accomplished on 21 July 1969 during the Apollo 11 mission. Built under von Braun's leadership, the Saturn V rocket was one of the largest and most advanced rockets ever built.

Since then, many people and considerable amounts of research equipment have been sent into space. Also, space stations orbiting Earth have been established. Space robots and rovers have been deployed to various planets. Satellites enabled scientists to study the Earth, forecast the weather and communicate instantly around the world. As the demand for increased payloads grew, it became necessary to design and build a wide range of powerful and versatile rockets and shuttles. The 21st century saw the space open up to commercial exploration and exploitation, creating opportunities for technological developments on an unprecedented scale. Their potential outcomes for the human, the economy and the environment are extremely promising, but they also involve an unpredictable element.

DID YOU KNOW THAT...

31 min on foot (2.5 km) / 10 min by bike (2.7 km) from ZAMEK Culture Centre

The PUT Rocketlab science club has been active at Poznań University of Technology since December 2017. It is composed of nearly 70 graduate and postgraduate students from many faculties and majors, including Automation and Robotics, Electronics and Telecommunications, Computer Science, Chemical Engineering, Safety Engineering, Mechanics and Mechanical Engineering, Mechatronics, Aerospace and Management Engineering. The team is supported by the scientific staff at the university. They all share a fascination with the development of space technology, designing and constructing highly efficient hybrid rocket engines or building student research rockets. Their HEXA 2 probe rocket won two awards at the largest international rocket engineering competition Spaceport America Cup 2021: one for Technical Excellence and another in the most technically advanced category, i.e. 30K SRAD Hybrid/Liquid. Built from from fibreglass, carbon fibre and aluminium, HEXA 2 has a hybrid drive, a diameter of 160mm and a length of 4.2m. Filled with fuel, it weighs 55 kg. It can reach an altitude of 10 km while its flight speed reaches 1,900 km/h.

19 h 43 min on foot (97 km) / 5 h 18 min by bike (104 km) from ZAMEK Culture Centre

Wernher von Braun (1912-1977), one of the most important rocket designers and advocates of space exploration in the 20th century, was born 111 years ago in Wyrzysk (formerly German Wirsitz) in Greater Poland. He was a key figure and originator of the American rocket programme. It was von Brown who created Saturn V: the largest and most technologically advanced rocket to date, which made it possible for the Apollo 11 mission to

succeed in landing man on the moon. However, his name also remains closely associated with the first ballistic missile, the V-2, which was envisaged to bring victory to Adolf Hitler's "Thousand-Year Reich". Its production relied on the labour of prisoners from the Mittelbau-Dora concentration camp, but von Braun—a member of the SS and creator of a deadly weapon— never felt responsible for war crimes. His work and commitment to the Nazi regime cast a long shadow over his merits as a pioneer of space conquest, raising still relevant questions about the ethical dimension and price of scientific achievement.

Space debris, most of which orbits the Earth, is the legacy of more than 60 years of human activity in space. According to the communication of the European Space Agency (ESA) published on 22 December 2022, 14,710 satellites have been placed on the orbit since 1967, of which more than 9,780 still remain there, but only 7,000 are operational. In addition, more satellites are currently being launched than ever before.

The United States System Space Surveillance Networks (SSN) detect, catalogue and monitor space debris. According to ESA's data for 2022, 30,000 pieces of space junk have been recorded so far: active and inactive satellites, spent rocket frames or fragments from collisions or explosions of satellites and rockets fragments. ESA models, however, speak of a much larger amount of space debris, as the number of objects larger than 1 cm may exceed 1 million.

Presence of space debris should also be associated with missions aboard the International Space Station (ISS). Such objects are taken back to Earth by the astronauts or dropped in special packages. The largest ever package of rubbish was thrown off the ISS in March 2021. The special pallet contained 2.9 tonnes of waste.

Developing a technology to clean up the debris on the orbit is currently one of the major goals of space industry. One draws up instructions on how to avoid space debris as well as develops spacecraft and satellite designs which minimize the risk of orbital littering. However, any undertakings in this respect are hampered by the lack of a proper space administration body and the absence of regulations which would protect space as part of our common heritage.

06 - THE SMALL BODIES OF POZNAŃ

Small bodies of the Solar System are a group of objects that orbit the Sun but which are neither planets, dwarf planets or natural satellites. They include asteroids, chiefly trans-Neptunian objects, comets, and other minor bodies such as meteoroids. The term "small bodies of the Solar System" was officially introduced by the International Astronomical Union in 2006. Such objects are the main focus of research at the Astronomical Observatory Institute, Adam Mickiewicz University in Poznań, where scientists are particularly concerned with planetoids.

The latter are irregularly shaped cosmic rocks, most of which orbit the Sun in the so-called Planetoid Belt, between the orbits of Mars and Jupiter. However, due to gravitational perturbations caused by the planets, as well as non-gravitational interference, the planetoids of the Main Belt approach the Sun, crossing the orbits of Mars, Earth, Venus and Mercury on their way.

PLANETOID DISCOVERIES

(1) Ceres – 1801
(10) Hygiea – 1849
(100) Hekate – 1868
(1,000) Piazzia – 1923
(10,000) Myriostos – 1951
(20,000) Varuna – 2000

(30,000) Camenzind – 2000
(100,000) Astronautica – 1982
(500,000) 2011 PM6 – 2011
(600,000) 2011 EG29 – 2011
(1,000,000) 2016
(1,263,571) all discovered to date – 2023

DO YOU KNOW THAT…

49 min on foot (3.8 km) / 14 min by bike (4.0 km) from ZAMEK Cultural Centre

On 22 September 1949, Jerzy Dobrzycki (1927-2004) and Andrzej Kwiek (1916-1953) discovered an asteroid using the now historical Zeiss telescope, located in the park of the Astronomical Observatory in Poznań. In honour of the city, the planetoid was named Posnania and given the catalogue number 1572. It remains the only asteroid discovered in our city so far.

Professors from the AMU Astronomical Observatory Institute have their own asteroids.

The names of asteroids are suggested by their discoverers, after they have determined the exact orbit of the object. The proposal for a particular designation is provided with a brief justification. The submitted names are evaluated by the 15-member Committee for Small Bodies Nomenclature (CSBN), which is part of the International Astronomical Union (IAU). The new names of asteroids become official following their publication in the Minor Planet Circular.

List of asteroids associated with Poznań and staff at the Poznań Observatory. Each name is followed by respective justification (based on data from the MPC).

Names include the following fields:
(number) name = provisional designation, date and place of discovery, discoverer
(based on data from MPC)

(7747) Michałowski = 1987 SO, 1987 09 19 Anderson Mesa, Bowell, E.
Named in honour of Tadeusz Michałowski (b. 1954), Polish astronomer and retired staff member of the AMU Astronomical Observatory in Poznań. Michałowski developed a formalism for calculating pole orientation, shape and sidereal rotation period of asteroids using the least-squares method, based on lightcurves. That method (or similar methods) are now widely used as a standard tool and have substantially improved the quality of such determinations. The name of the asteroid was suggested by H. Rickman.

(7789) Kwiatkowski = 1994 XE6, 1994 12 02 Palomar, Bowell, E.
Named in honour of Tomasz Kwiatkowski (b. 1965), Polish astronomer working at the AMU Astronomical Observatory in Poznań, Poland. Kwiatkowski specializes in accurate photometric observations of asteroids and determining their shape and pole orientation from lightcurves. The name of the asteroid was suggested by H. Rickman.

(10470) Bartczak = 1981 EW18, 1981 03 02 Siding Spring, Bus S. J.
Przemysław Bartczak (born 1974) is a scientist at the AMU Astronomical Observatory in Poznań, where he develops techniques for inverting lightcurves of asteroids, which then serve to calculate axis rotation positions, as well as the convex and non-convex shapes of such bodies.

(10471) Marciniak = 1981 EH20, 1981 03 02 Siding Spring, Bus S. J.

Anna Marciniak (born 1979) is a scientist at the AMU Astronomical Observatory in Poznań, whose work focuses on determining axis rotation positions and shapes of long-period asteroids of the main belt.

(10472) Santana-Ros = 1981 EO20, 1981 03 02 Siding Spring, Bus S. J.
Toni Santana-Ros (born 1984) is a former researcher at the AMU Astronomical Observatory in Poznań. He performs photometric measurements of small bodies to support the Gaia space mission.

(16406) Oszkiewicz = 1985 PH, 1985 08 14 Anderson Mesa, Bowell, E.
Dagmara Oszkiewicz (b. 1982) is an assistant professor at the AMU Astronomical Observatory in Poznań. Her research into asteroids includes analysis of photometric phase curves, spectroscopic observations and development of statistical methods for orbital inversion.

(21776) Kryszczyńska = 1999 RE221, 1999 09 05 Anderson Mesa, LONEOS
Agnieszka Kryszczynska (born 1965) is a specialist in asteroids at the AMU, studying physical properties of asteroids based on their photometric observations. She is credited with the discovery of the binary nature of the asteroid (809) Lundia, and runs a database of asteroid shapes and pole coordinates.

(24441) Jopek = 2000 FM29, 2000 03 27 Anderson Mesa, LONEOS
Tadeusz J. Jopek (born 1951) is a professor at the AMU. Author of cluster analysis methods used to identify meteoroid streams and describe their relation to near-Earth asteroids (NEOs).

(25052) Rudawska = 1998QG54, 1998 08 27 Anderson Mesa, LONEOS
Regina Rudawska (b. 1979) is a graduate of the AMU, and holds doctoral degree obtained at the Astronomical Observatory Institute in Poznań. Her scholarly achievements include the development of new tools which are employed to find similarities between meteoroid orbits as well as identify new meteoroid streams and their parent objects.

(30234) Dudziński = 2000 GD167, 2000 04 04 Anderson Mesa, LONEOS
Grzegorz Dudzinski (born 1989) is a graduate of the AMU and holds a doctoral degree obtained at the Astronomical Observatory Institute in Poznań. He studies the physical properties of asteroids and contributes to the development of new methods for modelling asteroid shapes.

(45492) Sławomirbreiter = 2000 AD241, 2000 01 07 Anderson Mesa, LONEOS
Slawomir Breiter (born 1963) is a professor at the AMU in Poznań. His scholarly work focuses on celestial mechanics, including contributions to analytic and semi-analytic theories of the YORP effect for asteroids as well as research on orbital dynamics.

(63440) Rożek = 2001 MD30, 2001 06 30 Anderson Mesa, LONEOS
Agata Rożek (born 1986) graduated in Astronomy from the AMU, and works as a researcher at the University of Kent (UK). She performs optical and radar observations of near-Earth asteroids to determine their shapes and rotational motion parameters as well as find evidence of non-gravitational forces to which they may be subject.

(72447) Polińska = 2001 DP, 2001 02 16 Ondrejov, Pravec P. & Sarounova L.
Magdalena Polińska (born 1981) is an assistant professor at the AMU Astronomical Observatory in Poznań. She specializes in photometric observations of small bodies of the Solar System. Her current research interests also include stellar spectroscopy and determination of the chemical composition of stars.

IS THERE A RISK THAT AN ASTEROID MAY ANNIHILATE EARTH?

According to the data released in May 2022, more than 29,000 asteroids were known to be found in close vicinity of the Earth, including over 2,200 potentially hazardous bodies, which is why a collision is only a matter of time. In order to prevent such an event, it is necessary to determine the orbit of the object in question and to assess the degree of danger. To that end, Prof. Richard Binzel (b. 1958) of the Massachusetts Institute of Technology develop the so-called Torino Scale in 1995. This is an eleven-degree scale which serves to assess the potential threat of a cosmic catastrophe posed by various objects approaching Earth from space. At present, all known asteroids have been classified with a value of zero on the Torino Scale, meaning no threat. It must be remembered that the Torino Scale describes the probability of an impact with in advance of 100 years; also, we are unable to observe asteroids coming from the direction of the Sun. This was the case with the Chelyabinsk Meteorite in 2013, the largest known space object to collide with Earth since the Tunguska disaster in 1908.

Assigning an appropriate degree of threat to an object involves determining the kinetic energy of the impact (vertical axis) and its probability (horizontal axis). If, over a period of 100 years, an object comes close to the Earth several times, a new danger rating will be determined for each close pass, whereby its degree is subject to change. The first assessment of the orbit is made after only a few observations, while the subsequent ones yield more precise orbit parameters.

SCALE DESCRIPTION
0 (white) – no hazard
1 (green) – normal
2, 3, 4 (yellow) – meriting attention by astronomers
5, 6, 7 (orange) – threatening
8, 9, 10 (red) – certain collisions

07 - THE VISTAS OF SKY

On a cloudless night and away from the city lights, we can admire the beauty of the firmament. Most of the radiant objects visible in the sky are stars. That breathtaking sight has fascinated people since ancient times, and the stars were some of the essential phenomena to attract attention of the early scientists. Although they have been studied for millennia, they still remain the main object of interest for modern astrophysics.

Looking at the sky with the naked eye, we can easily find dozens of distinctive groups of stars, known as constellations. In fact, a total of 88 constellations may be distinguished across the entire celestial sphere. This division was approved in 1930 by the International Astronomical Union. Under good conditions, other astronomical objects besides stars are visible to the casual observer: planets, galaxies, star clusters, nebulae, and comets. However, in order to be able to perceive them, one has to get far away from cities illuminated by artificial light. Hence, dark sky reserves and parks are the best place to go.

DID YOU KNOW THAT...

Assuming that our Sun is the size of a ball with a diameter of 20 cm and is located where you are standing now, the Earth would be the size of a grain of pepper some 26 steps away from you. In turn, the last planet in our system, Neptune, would be at the intersection of Św. Marcin and Ratajczaka streets, 450 m from ZAMEK Culture Centre.

Now suppose that the entire Solar System fits into a ball measuring 20 cm in diameter situated where you are standing, then the star closest to us, Proxima Centauri, would be found in the Citadel Park in Poznań, next to

where the sculpture *Unrecognised* by Magdalena Abakanowicz is to be found, i.e. 2.3 km from the ZAMEK Culture Centre.

Then again, if the Solar System were located where you are standing and the distance between the Sun and Neptune amounted to 1 m, then the star closest to us, Proxima Centauri, would be in the vicinity of San Francisco, some 9,238 km from ZAMEK Culture Centre.

DARK SKY RESERVES IN POLAND

There are only a few places left on land where the view of the beautifully starlit sky and the Milky Way can be truly enjoyed. This is because natural lighting of the sky is eclipsed by street lamps, large-format advertising, profusely illuminated office buildings and industrial zones. In the so-called dark sky parks, approximately 7,000 stars can be seen using unaided eye, whereas in the cities fewer than 200 are visible. This is a major problem not only for scientists (e.g. astronomers) or enthusiasts of astrophotography, but also for all inhabitants of the planet. The scale of light pollution is evinced in the fact that the outlines of the continents are readily discernible in the images taken at night by an orbiting satellite.

One of the ideas to tackle such a state of affairs is creating dark sky parks and sanctuaries. Such reserves have already been established in many places around the world. One of those is the Teide National Park in Tenerife, the first place ever where legal constraints have been put in place to protect the night sky.

Poland has seven such areas, the best known of which is the Bieszczady Stellar Sky Park. Located closest to ZAMEK Cultural Centre is the Dark Sky Sanctuary in the villages of Izdebno and Chalin in the municipality of Sieraków. A number of instruments has been placed at that particular site by the Astronomical Observatory Institute of the Adam Mickiewicz University in Poznań, which conducts much of its research there.

08 - WILL WE SET FOOT ON MARS?

Among the planets in the Solar System, Mars resembles Earth the most. The distance between the two is approximately between 56 and 400 million kilometres. This value varies and depends strictly on the position of the planets in their orbits. And although Venus is closer to us, the conditions on Mars are far more conducive to life. Mars is called the Red Planet because of its characteristic rusty colour—owing to the to the large amount of iron oxide (rust) on its surface—which distinguishes it from the other planets in the Solar System. Mars is a rocky planet similar to Earth, enveloped by a thin layer of atmosphere, with soil temperature reaching about 25˚C in warmer periods can. A day there lasts 24 hours and 37 minutes, but that is basically where the similarities end.

The atmosphere of Mars consists of 95% carbon dioxide, 3% nitrogen, 1.6% argon and trace amounts of oxygen and other gases. It is therefore impossible to breathe freely there. The atmospheric pressure is less than one per cent of its equivalent on Earth, and at night the temperature can drop to -140˚C. A Mars year lasts 686 Earth days. The mass of Mars is 1/10 of Earth’s, so the gravitational pull we would experience on Mars is three times less than on our planet. The water that used to flow over the surface of the Red Planet has been trapped as hydroxides in Martian minerals or as ice in the caps located near the poles.

Is it therefore possible to colonize Mars? Here, scientists need to solve a number of important issues. The primary difficulties concern the technical aspects of flying to and returning from Mars as well as creation of an infrastructure which would enable humans to stay on the Red Planet for an extended period of time. For that purpose, one needs to develop technologies which serve to modify, harvest and use the natural resources available on Mars.

Mental and physical endurance of the human body is another major problem. The Apollo mission reached the Moon in four days. With current technology, it would take about nine months to reach Mars, but a complete

mission including return to Earth could last two or three years. Throughout this time, astronauts would need food, water and oxygen, as well as protection from harmful solar and cosmic radiation. Radio signals from Earth to Mars can arrive with a delay of up to 22 minutes, so astronauts will feel much more isolated there, adding to the psychological stress of being confined to a small team in the restricted space of a spacecraft or base.

Once the first bases have been established on Mars, and then perhaps colonies, a new challenge will have to be tackled, namely terraforming, or making Mars more like Earth. This would involve initiating processes to change atmospheric pressure, atmospheric composition, temperature, restore liquid water and, consequently, reintroduce organic life forms.

In recent years, the conquest of Mars has been widely discussed in the media as the most popular space-related topic. Successive unmanned missions reaching Mars, including rovers navigating its surface, continue to provide more and more essential information which adds to our knowledge. Experiments in test conditions simulated on Earth suggests solutions by means of which the limitations may be overcome. Moreover, they make it possible to assess the impact of such conditions on humans.

Sounds like a story straight out of science fiction? Perhaps, but the history of space conquest shows us how much of what seemed like fiction at first eventually became fact.

DID YOU KNOW THAT...

9 hrs 57 min on foot (97.8 km) / 5 hrs 26 min by bike (105 km) from ZAMEK Culture Centre

Piła is home to a simulated space base, the Lunares Mobile Research Station. Its premises are a site of professional research and technological development in an experimental environment to test the designs as well as study the physiological and psychological effects of isolation on humans. The base was created by Space is More, a team of research engineers who develop theoretical concepts for off-Earth facilities and design research sites and laboratories on Earth. The company specializes in architecture, biological and chemical engineering, mechanical engineering and design. They aim to inspire and support young professionals and scientists, believing that opportunities for collaboration and a scientific platform one of the vital ways to achieve it. Their research and cooperation with various international institutions has resulted in numerous publications and reports on prospective manned missions to the Moon and Mars.

31 min on foot (2.5 km) / 10 min by bike (2.7 km) from the ZAMEK Culture Centre

The Poznań University of Technology is home to the CybAiR science club, whose main aims and tasks include developing software and autonomous solutions (also intended to work in extraterrestrial conditions), designing and building robots and mechatronic devices submitted for domestic and international competitions, as well as organizing courses in the basics of microcontroller programming, 3D modelling, PCB design and many other fields. The organization gathers enthusiasts of automation, robotics, computer science and mechanics, and focuses on fostering engineering and creative skills. Importantly, its activities span projects outside the classic fields of automation and robotics. The members also run workshops on building robots for students and hold open lectures with invited guests. Close cooperation with the scientific faculty at the Poznan University of Technology ensures extensive access to modern software as well as measurement and research apparatus. CybAiR also carries out a number of joint projects with leading institutions and research establishments.

11 h 44 min on foot (57.5 km) / 3 h by bike (59.5 km) from the ZAMEK Culture Centre

Poznań University of Technology expands its potential in the field of space technologies. This aspiration is evinced in the construction of a new aerospace research centre at the Kąkolewo Campus. The first phase of the undertaking involved issues related to the digitization of the airport, while the subsequent focuses on space

facilities. Thus, three projects were launched: SpaceRobot Testing Centre (OTRK), Aerospace Data Transmission (POLYITAN) and Poznań University of Technology Station for Satellite Object Observation, Surveillance and Tracking (SONSOS). The Space Robot Test Centre consists of 4 laboratories. The first is the Mars/Lunar Yard, which will be connected to the second: an analog mission control centre, featuring tunable delay and other simulated distortions. The third laboratory is dedicated to testing environmental conditions. Low friction and low gravity testing will be conducted in the fourth laboratory. All laboratories will be equipped with robots and other necessary testing equipment.

Poznań University of Technology has been a member of the ESA_labs network since March 2022. ESA_lab@PUT focuses on robotics, radio communications, missile systems and satellite observation. The collaboration with ESA also encompasses research projects in which the former PUT team operated as a consortium partner, such as the StarTiger Dropter, dedicated to testing European precision landing capabilities on Mars under terrestrial conditions. The second project started in September 2022 as part of the ESA OSIP programme “Cognition: distributed data processing system for lunar operations”. Poznań University of Technology will conduct an analogue lunar mission using a wheeled vehicle, i.e. a rover.

Mars Pathfinder mission (NASA)

mission start: 4 December 1996

end of mission: 27 September 1997

NASA’s first successful space probe mission using a self-propelled vehicle on Mars. On 6 July 1997, the Sojourner rover, weighing just 10.5 kg and powered by solar cells, descended to the planet's surface from the landing platform of the Mars Pathfinder probe. It transmitted 550 images to Earth and carried out an analysis of the chemical composition of Mars rocks.

Mars Exploration Rover dual mission (NASA)

mission start: 10 June (Opportunity) and 7 July 2003 (Spirit)

end of mission: 13 February 2019 (Opportunity) and 25 May 2011 (Spirit)

In January 2004, two identical rovers, Spirit and Opportunity, landed in two remote locations on Mars. The rovers traveled around the planet, exploring it mainly from a geological perspective. The aim of the mission was to learn more about the geological and climatic history of Mars. Consequently, it was possible to determine whether water is present on Mars and whether conditions for life to form have ever existed there.

Mars Science Laboratory mission (NASA)

mission start: 26 November 2011

mission ongoing

The mission managed to land the Curiosity rover on the surface of Mars in August 2012. This is a car-sized laboratory designed to study the Gale Crater. The objectives of the mission include studying the climate and geology of Mars, assessing whether the selected site inside the crater has ever provided environmental conditions conducive to microbial life (including investigating the role of water), and researching planetary habitability in preparation for human exploration. By 9 January 2023, the rover had covered a distance of 29.27km.

Mars 2020 mission (NASA)

mission start: 30 July 2020

mission ongoing

The mission is tasked with investigating the possibility of past life on Mars, analyzing Martian climate, geology, and gathering information to prepare future manned missions to Mars. The Perseverance rover landed on the surface of the planet in February 2021. In addition to sampling instruments, it is equipped with cameras, microphones and an Ingenuity drone.

09 - WHERE ARE THEY?

The magnitude of the universe far outstrips our imagination. On a clear night, we can see a few thousand stars with the naked eye. Even an amateur telescope will reveal millions more. Thanks to science, we know that stars are not randomly scattered in space, but combine into vast groups known as galaxies.

According to astronomers, the observable universe comprises at least 100 billion galaxies, and our Galaxy—the Milky Way—is home to at least 100 billion stars and at least as many planets. Why, then, should there be only one intelligent civilization in a space so vast?

Based on the knowledge of the origins of life on Earth, many scientists are convinced that it is possible for even the simplest form of life to develop if the right conditions exist somewhere in the universe,. However, the observations and research to date have not produced incontrovertible proof that life beyond Earth does exist.

The contradiction between the theoretically high probability of such existence in the cosmos and the absence of any evidence to that effect gives rise to a paradox, which is referred to as the “Fermi paradox”. It is named after the Italian Nobel Prize-winning physicist Enrico Fermi (1901-1954), who is credited with the famed "Where are they?", a question he asked in 1950. According to Fermi, the size and age of the universe suggest that there should be many technologically advanced extraterrestrial civilizations. Lack of pertinent evidence may therefore stem from the fact that the initial assumptions are incorrect and advanced life is much rarer than we think. It is also possible that our methods of observation are incomplete, flawed or that contact with distant worlds is yet to come.

Answers to the question concerning life in the universe are sought in various scientific fields: astronomy, biology, chemistry and philosophy. Astrobiology emerged as a distinct field of inquiry to investigate the possibility of the existence and development of life elsewhere in the universe. Finding irrefutable proof that life beyond Earth either exists or does not will undoubtedly be the most important discovery in human history.

DID YOU KNOW THAT...

From time to time, one makes discoveries which indicate that life beyond Earth is possible. For instance, presence of water was determined on Europa (a moon of Jupiter) and on the meteorite ALH84001 which, having fallen on Antarctica 13,000 years ago, was thought to bear indications of life from Mars. The meteorite contained traces of organic carbon compounds, resembling those which form during the decomposition of plankton or accompany the growth of certain bacteria.

In September 2020, a group of British astronomers reported that they had detected phosphine in the atmosphere of Venus. Phosphine is a substance that can be formed by living organisms as they function. On Earth, it is produced naturally as a metabolite of anaerobic bacteria. Although the most recent studies call the evidence of phosphine on Venus into question, the possibility of life on that planet is not ruled out. New observations of Venus, scheduled to take place in the coming years, may offer a conclusive answer.

More than 5,000 exoplanets are already known. The first exoplanet was discovered in 1988, while the first planet that could resemble Earth—Gliese 581c—was discovered in 2007. In 2017, NASA announced the

discovery of a system of seven Earth- and Venus-like planets located at a distance of “mere” 40 light years from Earth (a light year ≈ 9.5 trillion km) and orbiting the star Trappist-1, discovered in 1999.

1 hr 35 min on foot (7.6 km) / 28 min by bike (8 km) from ZAMEK Culture Centre

At the Institute of Environmental Biology, AMU Faculty of Biology in Poznań, Prof. Łukasz Kaczmarek conducts research on tardigrades. Tardigrades, otherwise known as water bears, are multicellular extremophilic animals inhabiting almost all terrestrial ecosystems. Prof. Kaczmarek’s research is concerned with the effects of hypomagnetic conditions on tardigrades. He is testing their ability to undergo long-term anhydrobiosis (a decrease in the body’s vital activity resulting from water deficiency) and resistance to various types of poisonous substances. Scientists also investigate the survival of tardigrades in the Martian regolith, as well as on other planets and moons.