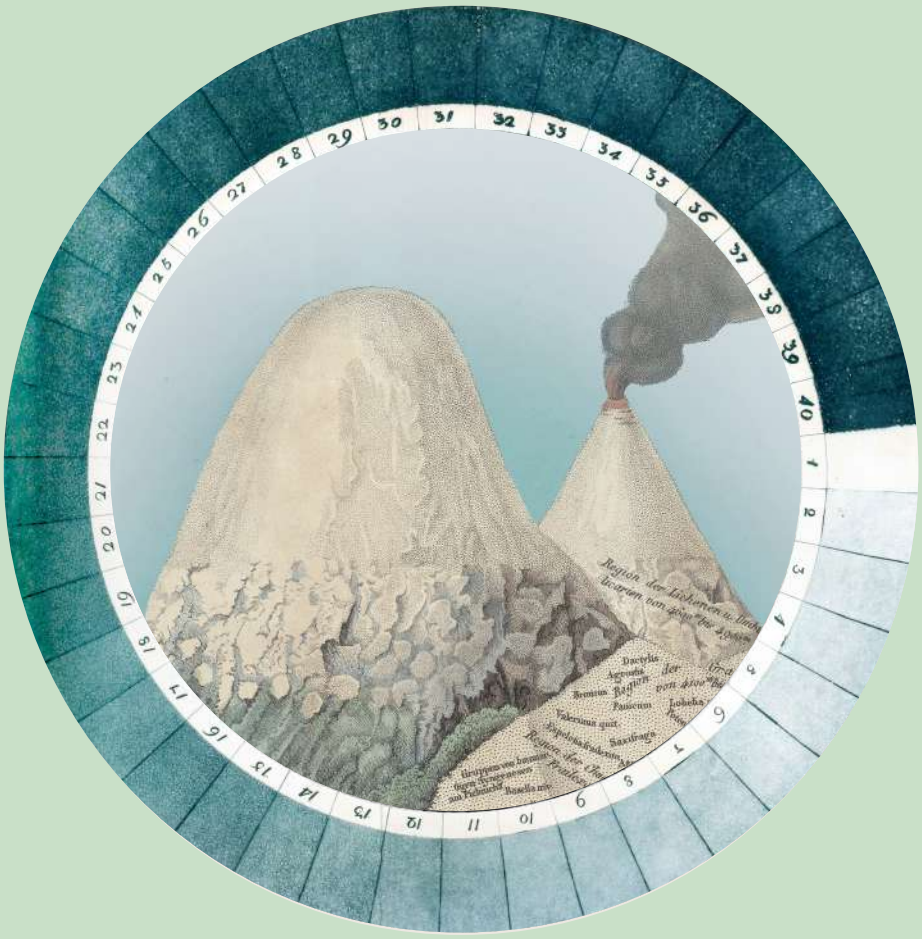
The instruments of HUMBOLDT



Tools for conceiving a new vision of nature

THE INSTRUMENTS OF HUMBOLDT.
TOOLS FOR CONCEIVING A NEW VISION OF NATURE.

ROOM 1

Participants wanted for an ambitious scientific expedition

In 1799, the young Prussian naturalist Alexander von Humboldt, together with the French botanist Aimé Bonpland, set off from the harbour of A Coruña bound for South America, with the aim of carrying out the most complete and exhaustive scientific exploration of the subcontinent.

Humboldt was convinced that nature was an inseparable whole: that natural physical phenomena and the geology of the terrain determined plant and animal life. He therefore set himself the primary goal of proving this through systematic observation and measurement.

To reach his goal, he equipped himself with a wide variety of the most advanced and precise scientific instruments available at the time. He carried out thousands of measurements, observations and analyses that allowed him to demonstrate the previous hypothesis, as well as develop new theories, establish new scientific disciplines and create an innovative vision of nature: *humboldtian* science

This exhibition shows how, thanks to his scientific instruments, Humboldt was able to build a new way of understanding, representing and disseminating nature as a web of connections.

Image caption:

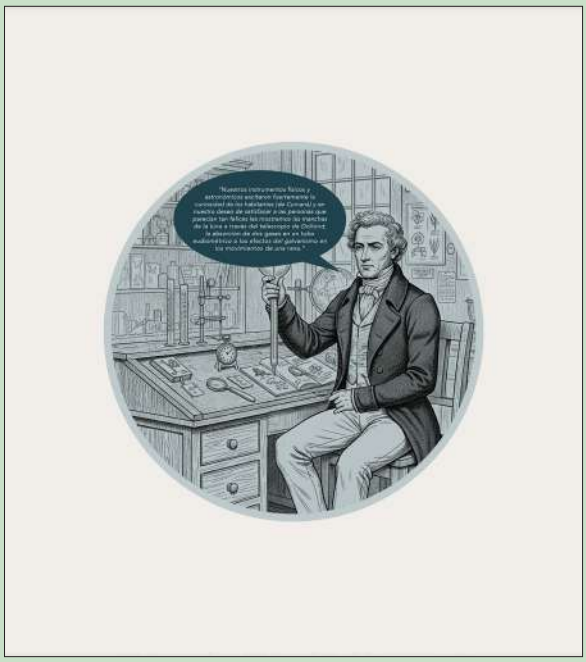
Drawing of the packet boat El Postillón de México in the midst of a raging sea.

Held at the Archivo General de Indias.

Ministerio de Cultura y Deporte. Archivo General de Indias (AGI), MP-INGENIOS, 259.

Illustrated quote

«Our physical and astronomical instruments greatly aroused the curiosity of the inhabitants (of Cumaná), and, following our desire to satisfy people who seemed so delighted, we showed them the spots on the Moon through our Dollond achromatic telescope, the absorption of gases in a eudiometric tube, or the effects of galvanism on the movements of a frog.».



THE INSTRUMENTS OF HUMBOLDT.
TOOLS FOR CONCEIVING A NEW VISION OF NATURE.

ROOM 2

The very best in scientific instruments

For his ambitious expedition, Humboldt assembled an impressive arsenal of scientific instruments. Each of the 42 devices he acquired—crafted from fine woods, glass and brass, and transported in its own velvet-lined protective case—was the most precise and/or most portable of its kind.

There were thermometers to measure air and water temperature; barometers to determine atmospheric pressure and altitude; quadrants and sextants for measuring latitude (including a pocket sextant); and chronometers and marine chronometers for calculating longitude. Telescopes, microscopes, a precision balance, compasses, a hygrometer, reagents and equipment for chemical analysis, electrical batteries, electrometers and electroscopes, a Leyden jar, theodolites, hygrometers, a magnetic inclination needle, and eudiometers to measure the percentage of oxygen in the air at different altitudes.

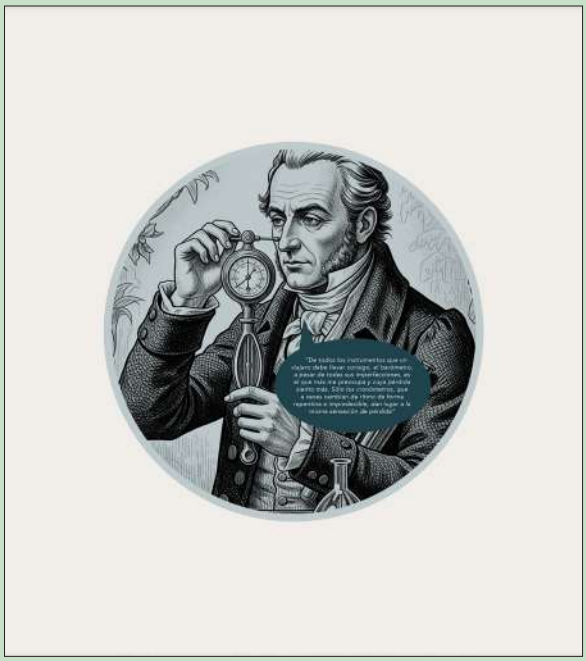
There were also a graphometer, a repeating circle, a cyanometer for measuring the blueness of the sky, a hypsometer, hydrometers, surveyor's chains, dissection kits, and many others.

Image caption:

Microscope after *Essays on the Microscope*, a work accompanied by 32 engraved plates detailing its structure and the technical advances in optical instrumentation of the period.

Illustrated quote

«Of all the instruments a traveller must carry with him, the barometer, despite all its imperfections, is the one that concerns me most and whose loss I feel most keenly. Only the chronometers, which sometimes change their rate suddenly and unpredictably, give rise to the same sense of loss.»



Thermometers to measure ocean currents?

To determine temperature, Humboldt equipped himself with a range of thermometers of different sizes and scales, including a thermometric probe to measure the temperature of the water at various depths from a ship.

During his voyage toward Ecuador, Humboldt carefully observed the water almost 1,000 km off the coast. Although native sailors and fishermen already knew that the water in that area was colder, no one had measured its temperature in a systematic way. Humboldt, obsessed with measuring everything, recorded both the temperature and the speed of this current. The data he collected made it possible to note that the water in this region of the Pacific is colder than in other parts of the ocean. While in other areas of the Pacific the water can be around 24 °C, in this band it is closer to 14 °C. He had just discovered the current that would bear his name —a finding that represented a major advance for science.

Image caption:

Sailor holding a thermometric probe submerged in the water.

Such an inclination deserves recognition

Humboldt felt a strong curiosity about measuring the intensity of the magnetic field. On his journey south through the Andes, using the dip circle, the naturalist confirmed that, as expected, the magnetic field decreased in intensity as he approached the equator. But to his surprise, after crossing it, the magnetic field continued to weaken until reaching a latitude of 7° south, more than 800 km from the geographic equator. Only then did the needle begin to reverse its direction and increase in intensity: he had just discovered the magnetic equator.

Strictly speaking, the needle of the dip circle indicates the direction and orientation of the Earth's magnetic field lines at each point. These lines point downward, toward the planet's core, at the north and south magnetic poles, and are horizontal at the magnetic equator.

Image caption:

A comparative view of the heights of the principal mountains and the lengths of the major rivers of the world.

London, 1844. Published by Henry Teesdale & Co. Drawn and engraved by J. Dower.

David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

1799–1804. Humboldt's Expedition

1. Embarks in A Coruña aboard the Spanish corvette *Pizarro*, stops in the Canary Islands, and continues to Cumaná.

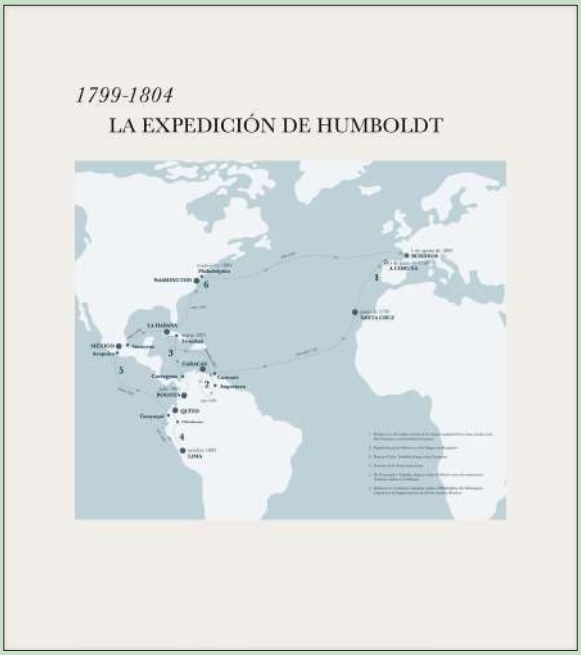
2. Expedition along the Orinoco and Rio Negro rivers with Bonpland.

3. Passes through Cuba and Trinidad, then visits Cartagena.

4. Crosses the Andes to Lima.

5. From Guayaquil to Acapulco, then stays in Mexico before embarking from Veracruz to Havana.

6. Embarks on the cargo ship *Concepción* bound for Philadelphia. In Washington, boards the French frigate *La Favorite* bound for Bordeaux.



The barometer, Humboldt's passion

For Humboldt, his barometers were the most important instruments of the expedition: he needed them to determine altitude accurately during his mountain ascents.

The barometer was invented by the Italian physicist Evangelista Torricelli in 1643 to demonstrate the existence of the atmosphere and measure atmospheric pressure. But it was his colleague, the Frenchman Blaise Pascal, who shortly afterward used it for the first time to determine elevation above sea level. As a general rule, pressure decreases by approximately 1 hPa (hectopascal) for every 8 to 10 meters of gained altitude. Knowing the uniform pressure at sea level allows the calculation of height.

Altitude was a key piece of data for Humboldt in his studies of biogeography, the new science he had conceived, which analyzes the distribution of organisms across the planet and the causes determining that distribution: geographic location, altitude, average temperature and its variability; atmospheric conditions; chemical composition of the terrain; and so on.

Image caption:

A new and improved view of the comparative heights of the world's principal mountains and the lengths of its main rivers. All carefully arranged from various existing sources.

By W.R. Gardner. London: William Darton, 58 Holborn Hill, March 10, 1823. Engraving by W.R. Gardner, 367 Strand. David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

THE INSTRUMENTS OF HUMBOLDT.
TOOLS FOR CONCEIVING A NEW VISION OF NATURE.

ROOM 2

The sextant and the chronometer, a marriage of convenience

The sextant proved to be the fundamental instrument for determining latitude. Humboldt included two of these instruments in his expedition, one of them portable or pocket-sized, of only two inches in radius and, in Humboldt's words, especially convenient for taking measurements on horseback or in a small boat.

Longitude, on the other hand, was determined using a precision marine chronometer that marked the reference time in Paris—then the prime meridian —with exact accuracy, which was then compared to the local time, determined on site.

Thanks to these instruments and the measurements taken with them, Humboldt introduced latitude and longitude as key new variables for understanding how vegetation changes: his idea was that it varies both with altitude and geographic position. This is evident even on the two faces of the same mountain.

Image caption:
Precision chronometer.

Image caption:
Historical engraving of an astronomical sextant designed by John Hadley (1682–1744) around 1730. AKG / Science Photo Library.

From measuring temperature to the invention of Isotherms

Wherever he went, one of the first things Humboldt did was measure and record the temperature of the land, air, and water —rivers, lakes, ponds, and coasts— using one of the thermometers he always carried on his travels.

These systematic and exhaustive temperature measurements —and their subsequent interpretation in connection with local vegetation and how it varies— allowed him to visualize and conceive the isotherms: lines that connect different geographic locations and show the same average temperatures (and ranges of variability), thus allowing us to visualize global climate patterns.

Isotherms, along with isobars (lines of equal pressure), are fundamental tools for meteorology and physical geography, designed to show the distribution of temperature across the Earth's surface and to compare the climates of different regions.

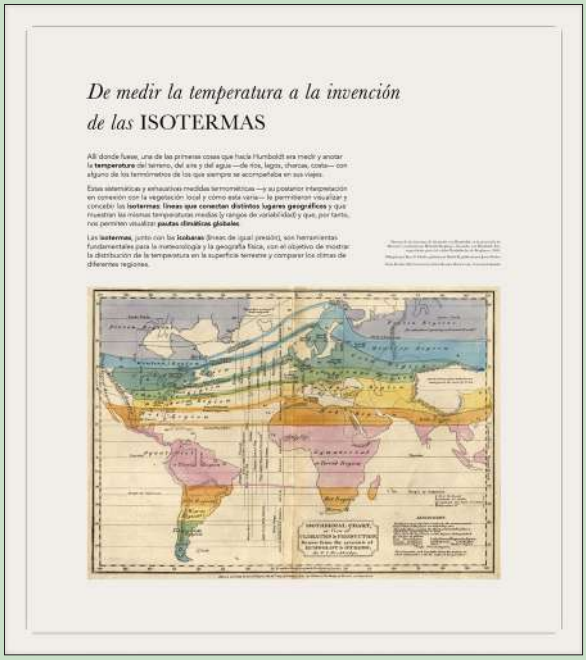


Image caption:
"System of Isotherms by Alexander von Humboldt, in Mercator projection," produced by Heinrich Berghaus and Alexander von Humboldt. This map is part of the *Atlas Physikalischer* by Berghaus, 1849.

Drawn by Bar and F. Schelle, engraved by Madel II, published by Justus Perthes. David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

ROOM 3

Humboldt in A Coruña: a general essay

Before departing for America aboard the frigate *Pizarro*, and due to adverse conditions that made setting sail inadvisable —and also because of the presence of English fleet ships nearby— Humboldt had to remain ten days in A Coruña.

The young Prussian naturalist used those days to test the instruments he had recently acquired in Paris and to carry out new and diverse measurements that allowed him to establish the position —longitude and latitude—o f the town of Ferrol using the chronometer and sextant; estimate the electricity in the air on a stormy day with an electrometer; measure the percentage of oxygen in the Coruña atmosphere with a eudiometer; test the inclinometer by measuring variations in magnetic declination; and record changes in the water temperature of the Coruña bay using the thermometric probe.

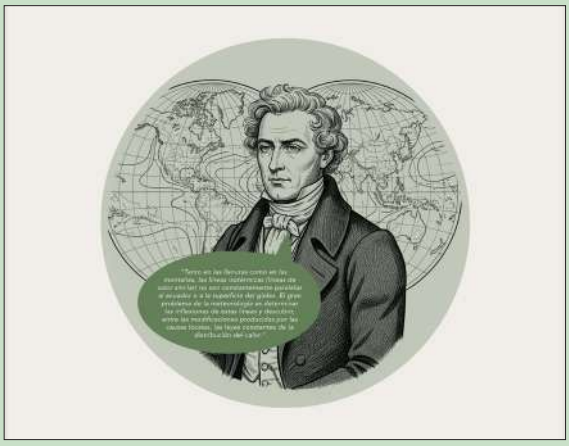
In addition, he explored the Coruña landscapes, collecting samples of the local flora and studying the algae and mollusks of the Herculean coast.

Image caption

Mariano Ramón Sánchez (1740–1822), *View of A Coruña*, 1792.

Cita ilustrada

«As on the plains and in the mountains, isothermal lines (lines of similar temperature) are not constantly parallel to the equator or to the surface of the Earth. The great problem of meteorology is to determine the inflection points of these lines and to discover, among the changes aproduced by local causes, the constant laws of heat distribution.»



Cita ilustrada

«Even when nature does not produce the same species in analogous climates, we can compare latitudes within the same hemisphere that present the same temperature, or we can consider the relationships that may exist between the vegetation of the two hemispheres under the same isothermal lines.

The geography of plants does not simply involve an examination of the analogies observed within the same hemisphere. It also investigates the relationships between alpine plants of both hemispheres.»

THE INSTRUMENTS OF HUMBOLDT.
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ROOM 3

The first great ascension

After hastily setting sail from A Coruña for America, the *Pizarro* made a brief stop in the Canary Islands. Humboldt took advantage of his time in Tenerife to climb Mount Teide and study and collect samples of its flora. This would prove fundamental in establishing his great work, "Geography of Plants." His sketch of the volcano shows the first distribution of plants he made according to altitude.

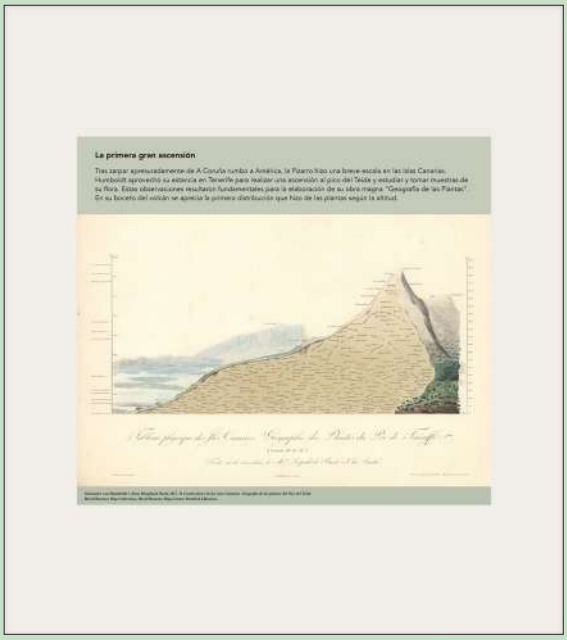

Image caption:

Alexander von Humboldt and Aime Bonpland. Paris, 1817. *II. Physical Chart of the Canary Islands. Geography of the Plants of Pico del Teide.*

David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

A Crucial Discovery

On his journey through Spain from France, which took him first along the coast of Catalonia and the Levante region and then inland to Madrid to visit the Court, Humboldt made numerous topographic and barometric measurements to determine altitude. These measurements allowed him to create the first topographic profile of the Iberian Peninsula in the first half of 1799, which scientifically demonstrated the presence of the central plateau of the peninsula.

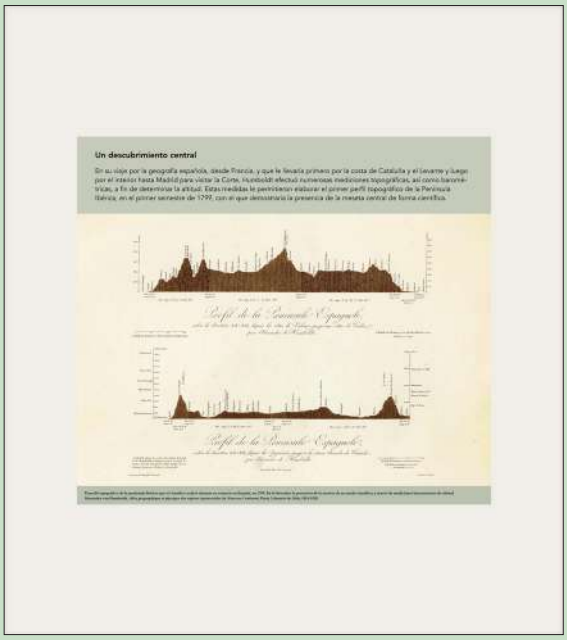

Image caption:

The topographic profile of the Iberian Peninsula that the scientist created during his stay in Spain in 1799. In it, he scientifically identifies the presence of the plateau through barometric measurements of altitude.

Alexander von Humboldt. *Atlas géographique et physique des régions équinoxiales du Nouveau Continent*, Paris, Librairie de Gide, 1814-1838.

THE INSTRUMENTS OF HUMBOLDT.
TOOLS FOR CONCEIVING A NEW VISION OF NATURE.

ROOM 3

Notice to Mariners

During his stay in A Coruña, Humboldt took the opportunity to study how the temperature of the seawater varied during a boat journey across the Coruña bay to Ferrol. He thus observed that "the proximity of a sandbank is indicated by a rapid drop in sea temperature."

Bring your ship safely to port!

Sail from A Coruña to Ferrol in the shortest possible time and without running aground, using the thermometer as your guide: if the temperature drops, change course to avoid the shoals.

Image caption:

Digitized image from the British Library of page 219 of *Voyage of the Austrian Frigate Novara Around the World in 1857–1859 under the command of Commodore B. von Wüllerstorf-Urbair.* (Physical and geognostic observations by A. von Humboldt.) British Library, Digital Store 10027.g.10.

Do you know how to use a sextant?

The sextant is an instrument that allows you to measure the angular height of celestial objects relative to a point on the horizon. From the readings obtained with this instrument, sailors could determine the latitude at which they were located.

Its operation is not especially simple or intuitive. Practice is necessary:

1. Hold the sextant with the telescope at eye level.
2. Aim the sextant at the horizon through the horizon mirror.
3. Unlock the clamp screw and move the index arm to bring the reference star (or point of light) down until it rests on the horizon.
4. The value indicated by the index arm on the graduated arc is the "instrumental altitude," which, after some calculations, allows you to find the true altitude and consult the nautical almanac to determine the latitude.

THE INSTRUMENTS OF HUMBOLDT.
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ROOM 3

Longitude with a marine chronometer

In the 18th century, geographic longitude was calculated using Paris time as a reference (at that time, the Paris meridian was considered 0°) indicated by a precision marine chronometer, capable of withstanding the motions of open-sea navigation without losing accuracy. Paris time was compared with the local time, determined on site. Knowing that each hour of difference corresponds to 15° of longitude (each minute equals ¼ of a degree), sailors could calculate the degrees of difference relative to the 0° meridian—that is, geographic longitude.

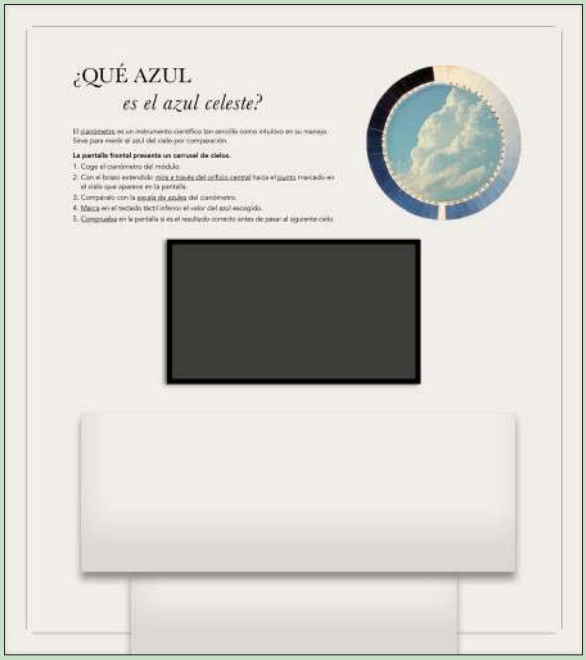
Try it yourself: select the local time on the lower touchscreen. On the upper screen, you can see your geographic longitude and the distance from Paris.

Which blue is the sky blue?

The cyanometer is a scientific instrument as simple as it is intuitive to use. It is used to measure the blueness of the sky by comparison.

The front screen displays a carousel of skies.

1. Take the cyanometer from the module.
2. With your arm extended, look through the central hole at the point in the sky indicated on the screen.
3. Compare it with the blue scale on the cyanometer.
4. Enter the value of the chosen blue on the lower touchscreen.
5. Check the screen to see if your result is correct before moving on to the next sky.



THE INSTRUMENTS OF HUMBOLDT.
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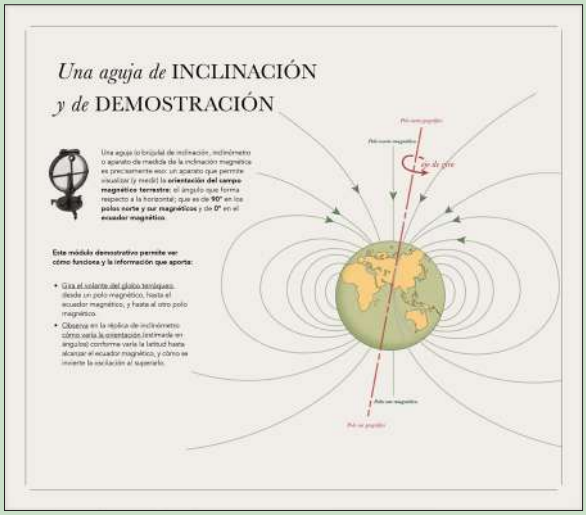
ROOM 3

A needle for inclination and demonstration

A dip needle (or circle), inclinometer, or magnetic inclination measuring device is exactly that: an instrument that allows you to visualize (and measure) the orientation of the Earth's magnetic field —the angle it forms relative to the horizontal; 90° at the north and south magnetic poles and 0° at the magnetic equator.

This demonstration module allows you to see how it works and the information it provides:

1. Turn the globe's wheel from one magnetic pole to the magnetic equator, and then to the other magnetic pole.
2. Observe on the dip needle replica how the orientation (measured in degrees) changes as latitude varies until reaching the magnetic equator, and how the oscillation reverses after crossing it.



A barometer to be up to the task

The barometer was a fundamental instrument for Humboldt when determining altitude based on atmospheric pressure, since pressure decreases as we ascend from sea level.

This interactive allows you to experience how pressure varies with altitude:

Adjust the altitude using the touchscreen selector and observe how the pressure changes on the barometer on the front screen as the hot-air balloon rises or descends.

Image caption:

The physical world, 1882. "Torricelli Experiment – Effect of Atmospheric Gravity."

University of Seville's Library's Old Fund

THE INSTRUMENTS OF HUMBOLDT.
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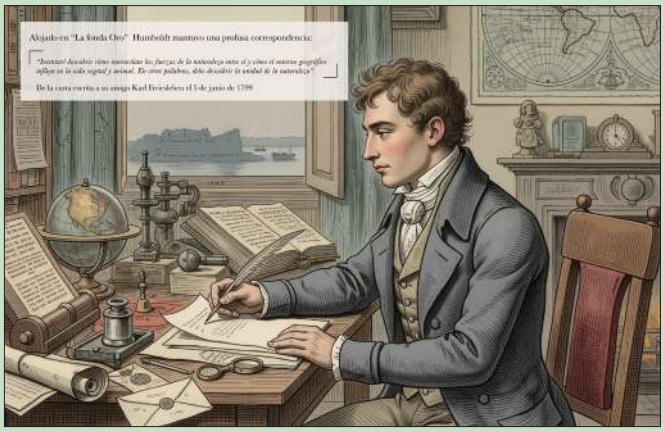
ROOM 3

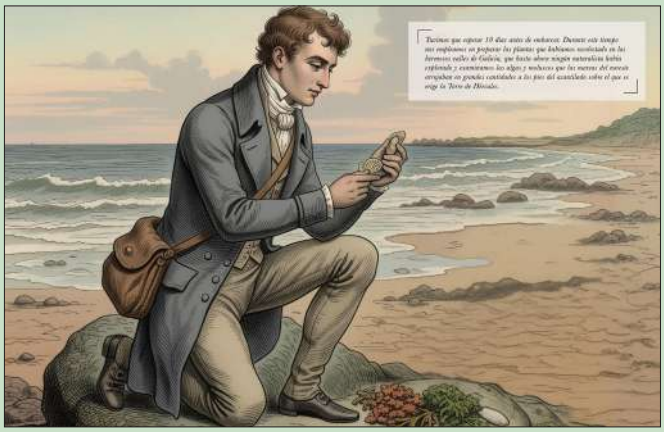
Staying at "La fonda de Oro," Humboldt maintained an extensive correspondence:

"I will attempt to discover how the forces of nature interact with one another and how the geographical environment influences plant and animal life. In other words, I must discover the unity of nature."

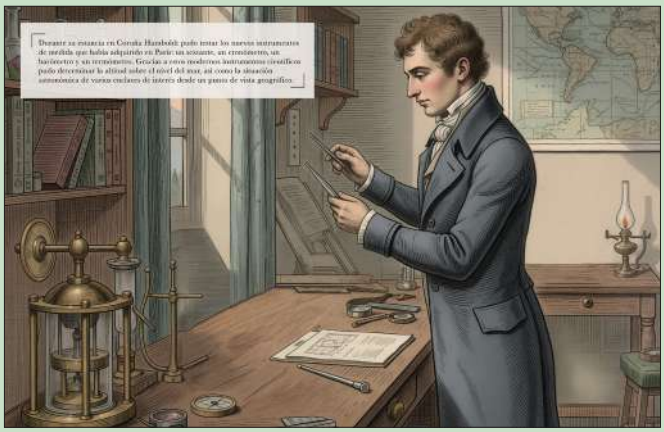
From the letter written to his friend Karl Freiesleben on June 5, 1799.



"We had to wait ten days before embarking. During this time, we focused on preparing the plants we had collected in the beautiful valleys of Galicia, which until now no naturalist had explored, and we examined the algae and mollusks that the northeast tides threw in large quantities at the foot of the cliff on which the Tower of Hercules stands."



During his stay in Coruña, Humboldt was able to test the new measuring instruments he had acquired in Paris: a sextant, a chronometer, a barometer, and a thermometer. Thanks to these modern scientific instruments, he was able to determine altitude above sea level, as well as the astronomical position of several sites of interest from a geographic point of view.



"Repaired in 1788, the Tower of Hercules measures 92 feet in height, its walls are 4½ feet thick, and its construction clearly shows that it was built by the Romans. [...] At its top, and since the most remote times, a charcoal fire has been maintained to guide ships."

THE INSTRUMENTS OF HUMBOLDT.
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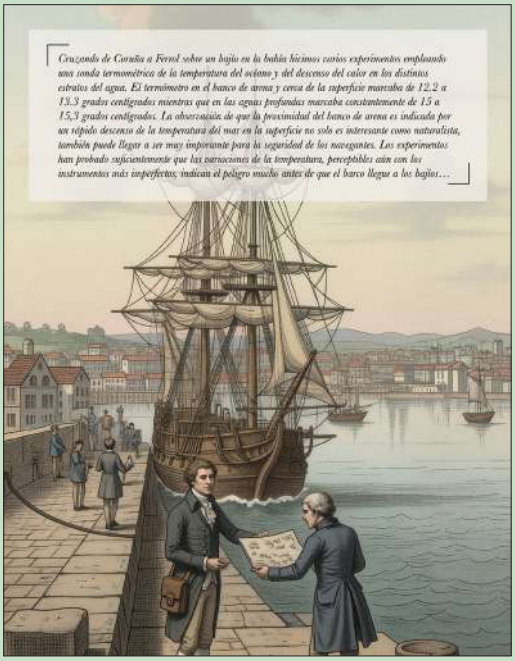
ROOM 3

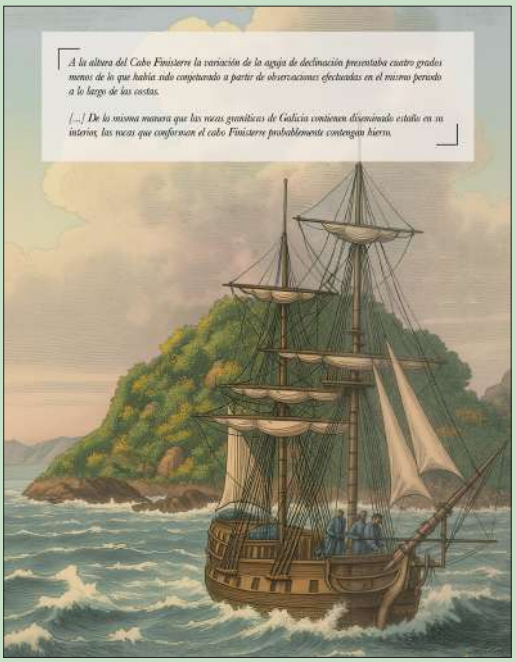
"These days I keep in mind one of my role models: the great naturalist and explorer Alejandro Malaspina, who is sadly imprisoned in the Castle of San Antón, the fort-prison of A Coruña."

"Crossing from Coruña to Ferrol over a shoal in the bay, we conducted several experiments using a thermometric probe to measure ocean temperature and the decrease of heat in the different layers of water. The thermometer at the sandbank and near the surface marked 12.2 to 13.3 degrees Celsius, while in the deeper waters it constantly read 15 to 15.3 degrees Celsius. The observation that the proximity of a sandbank is indicated by a rapid drop in surface sea temperature is not only interesting as a naturalist, but can also be very important for the safety of sailors. The experiments have sufficiently proven that variations in temperature, perceptible even with the most imperfect instruments, indicate danger long before the ship reaches the shoals…"



"At the height of Cape Finisterre, the variation of the dip needle was four degrees less than had been conjectured based on observations made during the same period along the coasts.

[...] Just as the granitic rocks of Galicia contain tin scattered within them, the rocks forming Cape Finisterre probably contain iron."



A new science, a new vision of nature

In August 1804, Humboldt returned to Paris. He had been traveling for more than five years and came back with hundreds of drawings and tens of thousands of notes and measurements of all kinds. He had collected specimens of 6,000 plant species, a third of which were previously unknown. But he also returned with his mind full of intuitions.

An immense collection of data, measurements and ideas allowed him to make astonishing discoveries, conceive and anticipate revolutionary theories, and create a new science: biogeography, or plant geography. He also developed a new vision of the world in which all the forces of nature are interconnected.

To explain it, he developed a revolutionary way of presenting scientific information: through striking illustrations, which he called *Naturgemälde* ("painting of nature") —as attractive and suggestive as they were ideal for visualizing the connections between the different forces of nature and how these determine life.

Image caption:

Humboldt's Physical Tableau. This diagram, published in *Essay on the Geography of Plants*, 1807, presents a sectional view of the Chimborazo and Cotopaxi volcanoes with the distribution of their vegetation according to altitude. Humboldt later made several corrections to this work. After reanalyzing the samples, it was found that the vegetation described actually belonged to Mount Antisana [Pierre Moret et al., 2019]. Zentralbibliothek Zürich.

Naturgemälde ("Painting of Nature")

The original *Naturgemälde* was a 90 × 60 cm colored fold-out engraving that showed Mount Chimborazo in cross-section and the distribution of plants from the valley to the snow line. In the sky, the heights of other known mountains and the altitude reached by Gay-Lussac during his balloon ascents were indicated. On the left and right sides of the mountain, there were up to 16 columns in which, along with altitude in meters and toesas (equivalent to 1,949 m), the variation of different parameters and natural phenomena according to altitude was recorded: light refraction; atmospheric electrical phenomena; vegetation, species, and crops; decrease in gravity; relative humidity; pressure, temperature, chemical composition, and intensity of the sky's blue; and so on.

In short, it was a comprehensive visual representation showing the correlations between animal and plant life according to altitude, latitude, and atmospheric, meteorological, and terrain conditions.

THE INSTRUMENTS OF HUMBOLDT.
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ROOM 4

The geography of life

Humboldt's working method was based on four fundamental principles: explore, collect, measure, and connect. During his expedition, wherever he was, he observed and recorded the forms, types, and behaviors of flora and fauna and collected specimens of plants, animals, and minerals, while also taking all kinds of measurements: he determined geographic position with the greatest precision; measured the quality of sunlight (by assessing the blueness of the sky); recorded precipitation and humidity; analyzed the chemical nature of the soil and atmosphere; and more. With all this information, he sought to establish connections, identify causes and effects, and ultimately visualize global patterns.

In this way, he conceived a novel approach to studying the natural world, which led to the birth of a new discipline: plant geography, or biogeography—the branch of science that studies the distribution of living beings across the planet according to environmental conditions.

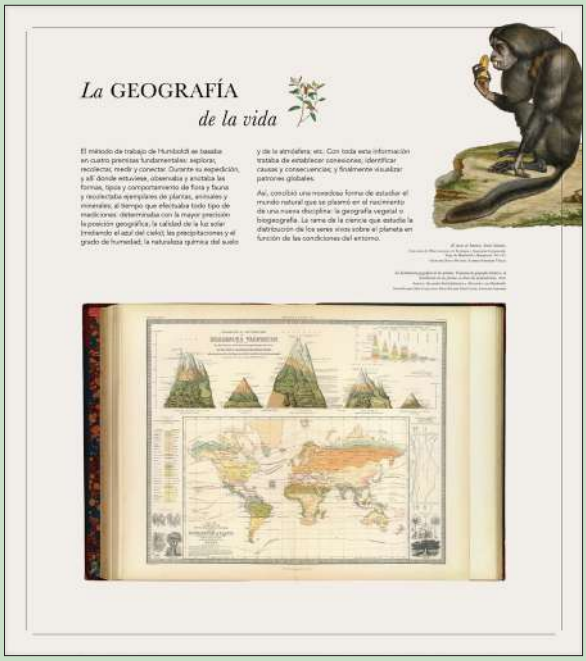

Image caption:
The Satan Monkey. Simia Satanas. Collection of Observations in Zoology and Comparative Anatomy. Voyage of Humboldt and Bonpland, 1811–33. World Bank Group / Lambert Schneider Verlag

Image caption:
The Geographical Distribution of Plants. Botanical geography diagram, showing the distribution of plants in a perpendicular direction, 1850. Authors: Alexander Keith Johnston and Alexander von Humboldt. David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries

Pioneer of ecology

Humboldt was the first to understand that climate results from the interaction between the atmosphere, oceans, and continental masses. To these, as he observed during his expedition, a new factor had to be added: human activity. This activity was considered another "force of nature" that needed to be taken into account, measured, and evaluated, as it was increasingly influencing the climate —and, consequently, biogeography.

This led him to list three ways in which humans were affecting the climate: deforestation, uncontrolled irrigation, and the large amounts of CO_2 and other gases produced in industrial centers. He also warned and sought to caution us about our irresponsible treatment of nature. Today, the bioclimatic zones reflected by Humboldt in his *Naturgemälde*, or "paintings of nature," have shifted many meters in altitude or have disappeared due to anthropogenic global warming.

Image caption:
Illustration of the Colorado River near the mouth of the Diamante River, highlighting the river's geography and surrounding terrain, 1861. Author: Heinrich Balduin Möllhausen (1825–1905)

THE INSTRUMENTS OF HUMBOLDT.
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ROOM 4

Humboldt's legacy in cartography

The example and success of Humboldt's *Naturgemälde*, with their combination of visual appeal and scientific rigor, quickly made an impression on contemporary geographers and scientists. Perhaps the clearest example of this is the decisive influence he had on the German geographer and cartographer Heinrich Berghaus. Inspired by Humboldt's representations of nature —and also encouraged by the naturalist, whom he had met in 1815 and with whom he maintained contact— Berghaus conceived in 1838 the first physical maps, which a few years later, in 1845, led to the publication of his *Physikalischer Atlas*. This was the first physical and thematic atlas.

Image caption:
World map for an overview of the distribution of solid and liquid features. Heinrich Berghaus, *Physikalischer Atlas* (Physical Atlas), vol. 1, 1845. David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

Image caption:
Idealized section of the Earth's stratigraphy, showing representative fossils from those layers. Heinrich Berghaus, *Physikalischer Atlas* (Physical Atlas), vol. 1, 1845. Courtesy of The Linda Hall Library of Science, Engineering & Technology.

Naturgemälde, an essential tool for scientists

In addition to being a carefully crafted and beautiful illustration, the *Naturgemälde* was a highly useful scientific instrument for naturalists, as it presented a wealth of information in a readily visible way. This interactive allows you to experience it:

1. The lower screen displays a multiple-choice quiz.
2. Select an answer to the question shown on the screen.
3. Check at a glance whether you were correct (or what the correct answer was) on the *Naturgemälde* before moving on to the next question.

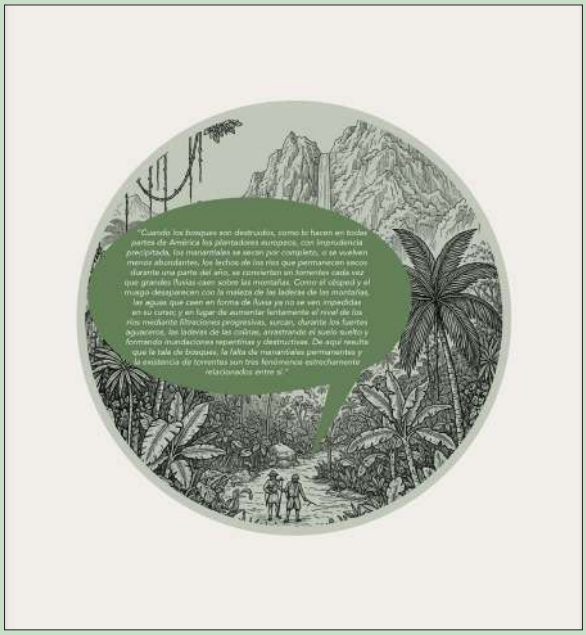
Image caption:
Journey to the Summit of Chimborazo, carried out on June 24, 1802. *Geography of Plants in the Andes of Quito.* David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

THE INSTRUMENTS OF HUMBOLDT.
TOOLS FOR CONCEIVING A NEW VISION OF NATURE.

ROOM 4

Illustrated quote

"When forests are destroyed, as European planters recklessly do everywhere in America, springs dry up completely or become less abundant, and riverbeds that remain dry for part of the year turn into torrents whenever heavy rains fall on the mountains. As the grass and moss disappear along with the undergrowth on the mountain slopes, the rainwater is no longer impeded in its course; and instead of slowly raising the river levels through gradual infiltration, it rushes down the hillsides during heavy downpours, carrying loose soil and causing sudden and destructive floods. Hence, deforestation, the lack of permanent springs, and the existence of torrents are three phenomena closely connected to one another."



Exhibition credits


Exposición temporal:

LOS INSTRUMENTOS DE HUMBOLDT
Herramientas para concebir una nueva visión de la naturaleza

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Xosé Antón Fraga Vázquez

Temporary exhibition: *THE INSTRUMENTS OF HUMBOLDT. Tools for conceiving a new vision of nature.*

Ministry of Science, Innovation and Universities
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State Secretary for Science, Innovation and Universities
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Xosé Antón Fraga Vázquez

+INFO

SAUSSURE HYGROMETER

Lerebours et Secretan

1835-1870

MUNCYT. CE1985/004/0039

The hair hygrometer, or Saussure hygrometer, named after its inventor, the Swiss naturalist, mountaineer, and meteorologist Horace-Bénédict de Saussure, is a meteorological instrument that allows the measurement of the relative humidity of the air: the amount of water present in the atmosphere in gaseous form or as tiny suspended droplets. It belongs to the so-called absorption hygrometers, which are based on the property that many organic substances have of lengthening in humidity and shortening in dryness, with hair hygrometers being the most commonly used due to the sensitivity of hair. Hair hygrometers use a tensioned hair: when the environment is humid, it lengthens, and when it is dry, it shortens. Changes in length are indicated by a needle on a relative humidity scale, which has been previously calibrated by exposing the hair to a completely dry environment and to another saturated with water vapor.

This particular specimen was manufactured by the prestigious Parisian firm Maison Lerebours et Secretan, specialized in the construction of highly precise optical and scientific instruments, between 1835 and 1870, when the house was at the height of its prestige, as evidenced by the fact that it supplied the Observatoire de Paris.

The most remarkable feature of this Saussure hygrometer is that it uses a human hair —other models used horsehair, which was what the inventor used in the prototype— tensioned and degreased to facilitate the absorption of environmental moisture. Specifically, this one has a blonde hair, which apparently deforms more consistently. The hair is attached to the frame at its upper end. The lower end is tied to a pulley, with an indicator needle on its axis, from which hangs a tiny weight: when humidity increases, the hair lengthens, causing the weight to rotate the pulley and its needle in one direction. If it shortens, the pulley and needle rotate in the opposite direction on the scale.

Since its invention in 1783, this type of hygrometer was widely used until the mid-20th century, when more precise instruments emerged.

THEODOLITE

George Adams

1755-1765

MUNCYT. CE1985/004/0354

The origin of the theodolite is uncertain. It is believed to date back to the 16th century, but neither the exact year nor its inventor is clear. In fact, it is possible that similar instruments were developed independently by different inventors around the same time. Some sources claim it was invented in 1615 by the Dutchman Snellus, based on the *quadratum geometricum*, an instrument developed by Tycho Brahe; other sources point to the British cartographer Leonard Digges as its inventor, or at least the creator of a precursor instrument, as early as 1551. This latter hypothesis is supported by the fact that Digges coined the term "theodolite" in his *Pantometria* of 1571, where he described a horizontal circle divided into 360 degrees, used to measure horizontal angles, a description that aligns much more closely with a simpler, more minimalist predecessor than with a classic theodolite like the one on display, crafted by the renowned optical and scientific instrument maker George Adams Sr. —whose son succeeded him as a master instrument maker— and who eventually became the instrument maker to King George III of England.

In any case, from its emergence, the theodolite became the instrument par excellence for precise angular measurements and thus a fundamental tool in astrophysics, geodesy, and surveying.

Beyond its apparent visual appeal, the key to its operation lies in the two perpendicular graduated rings or arcs on which the telescopic sight is mounted. These allow precise measurement of the angular distance covered by the sight in the vertical and/or horizontal plane. The screws allow the positions of both the sight and the graduated circles to be fixed: the sight is first aimed at one object or reference point, the origin of the circle is fixed at that point, and then the sight is moved to point at a second object. The position of the sight is fixed, and the angle indicated can then be read.

+INFO

RAIN GAUGE

1870-1900

MUNCYT. CE1985/004/0932

In her essay "*The Infinity in a reed*" Irene Vallejo points out that the most perfect inventions are those that have undergone almost no changes since their creation, as is the case with the pencil or the book. In this category, the seemingly humble rain gauge should also be included, a meteorological instrument that appeared centuries before Christ and has essentially remained the same: it is basically a graduated container that allows the collection and measurement of the amount of rainfall over a given period of time in a specific area —or, more precisely, the number of liters per square meter.

Rain gauges arose independently in different parts of the world from ancient times: in India around the 4th century BCE, in Asia Minor in the 1st century CE, and in China in the 13th century. However, in Europe they are not recorded until 1639, thanks to the Italian Benedetto Castelli. It would not be until a century later that their use spread and became popular, driven by the growing interest in the newly established discipline of meteorology.

The instrument on display belongs to the category of conical rain gauges: these consist of two cylindrical bodies fitted together to minimize losses due to splashing or evaporation. The upper part is funnel-shaped or conical and serves to collect water and deposit it into the lower, graduated section, which allows for measurement. It is likely that the first conical examples were built in Prussia around 1717. It was also at that time that systematic rainfall measurements began, with periodic records of precipitation aimed at establishing annual climate patterns to improve agricultural production.

This rain gauge also falls into the category of non-recording instruments, as it only documents the total amount of water collected over a period of time, without showing how the precipitation evolved during that interval. Recording rain gauges —practically rain recorders or pluviographs— perform this task, documenting rainfall on a graph paper.

SURVEYOR'S CHAIN

1850-1930

MUNCYT. DE1995/022/0006
(DEPÓSITO DEL INSTITUTO GEOGRÁFICO NACIONAL; MINISTERIO DE FOMENTO)

Also called the Gunter's chain in honor of its inventor, the English clergyman and mathematician Edward Gunter, who conceived it around 1620.

The surveyor's chain is a distance-measuring instrument notable for its practicality: it compensates for its lack of precision and low sensitivity with great ease of use, making it ideal for measuring distances over uneven terrain and in applications where extreme accuracy is not required, such as surveying.

Its design could hardly be simpler, nor its use more intuitive: the chain consists of a series of rigid metal rods, each 20 cm long, connected by links and finished with a handle at each end. These handles, along with the intermediate links, allow the insertion of pins, which, when driven into the ground, keep the chain taut and prevent it from slipping. In practice, the chain was typically operated by two people: one at the front with a set of pins, inserting them as the rods were laid out, and another at the rear holding the end of the chain, collecting the pins, and keeping track of the distance. When the person at the front fully extended the chain before completing a measurement, they would wait for their companion to catch up before moving on and repeating the process.

The original chain was 22 yards, or 60 feet, long. A choice that now seems odd, but made perfect sense at the time: 10 chains equaled a furlong, 80 chains a mile, and an area of 10 by 10 chains corresponded to an acre. Moreover, the 22-yard length of Gunter's chain defines the exact length of a cricket pitch —a matter with which no Englishman would compromise.

+INFO

ELECTROSCOPE

1853-1858

MUNCYT. CE1985/004/0375

Electroscopes are among the oldest tools in the scientific instrument arsenal, and also the first instrument for "measuring" electricity. Not surprisingly, the first electroscope was invented by the English physicist William Gilbert at the dawn of the 17th century to detect the presence of electric charge on a body. Its age explains its limited capacity (and the quotation marks around "measurement"), since it can only detect the presence of electric charge and, at best, provide a qualitative estimate.

Classic electroscopes fall into two main categories: the elderberry-sphere type, the first to be invented in 1754 by the British physicist John Canton, which were very simple and limited; and the gold-leaf type, developed in 1787 by the British physicist Abraham Bennet, which were more sophisticated and sensitive.

Interestingly, this model is a hybrid of the two: although it contains two elderberry spheres, its design and operation are directly related to the gold-leaf type. The elderberry spheres are located at the ends of two metal wires that hang from the top of a sealed glass bell, connected to a metal rod passing through the lid and topped by a metal ball. When a (presumably) electrically charged body is brought into contact with the ball, the charge flows along the rod to the two wires and finally to the surface of the elderberry spheres —an insulating material— which then acquire the same electric charge. This generates a repulsive force between the spheres, causing them to move apart, with the separation increasing as the charge increases.

The two vertical metal rods rising from the base serve a protective function: if the spheres were to touch the glass while separating, they could be damaged. These rods prevent that from happening, as contact with them allows the elderberry spheres to discharge and return to their original positions.

MICROSCOPE

John Cuff
1760-1770

MUNCYT. CE1985/004/0943

Microscopes, as we understand them —those we have all looked through at some point— are, strictly speaking, compound microscopes, meaning they have two or more lenses in their optical system. This contrasts with so-called simple microscopes, which were essentially high-magnification single lenses.

It is believed that the (compound) microscope was invented by the Dutch Jansen brothers, renowned makers of eyeglasses and lenses, who were the first to place two lenses at the ends of a hollow tube and observe that they magnified the smallest objects. However, the first practical or modern compound microscope is considered to be the one devised by Robert Hooke in 1603. Hooke's microscope is an example of a tripod microscope —so called because it was mounted on a stand rather than held by hand like a magnifying glass— and it consisted of three lenses, one in the objective and two in the eyepiece, as well as a light source to increase sample illumination.

The design of microscopes changed very little over the next two centuries. Evidence of this is this microscope, made by the prestigious manufacturer John Cuff. It is also a tripod —or stand— microscope, and, like Hooke's, incorporates three lenses in the tube and a system for illuminating the sample. The main difference is the focusing system: Hooke's used four concentric, extendable tubes, whereas this one uses a vertical micrometer screw that allows precise adjustment of the optical system's position.

The micrometer screw was introduced to microscopes by Cuff around 1745. In this specimen, it can be seen just behind the top end of the vertical support. If one looks closely, the support is composed of two bars, pillars, or flat pieces —one fixed and one movable— that slide against each other. The screw is attached at one end to the fixed bar and at the other end to the movable one, so turning it allows slight displacement of the movable bar and, therefore, fine adjustment of the optical system's position. This model is equipped with six objectives of varying magnification.

+INFO

BAROMETER

A. Masino & Co. 1840-1860

MUNCYT. CE1985/004/0017

The barometer, an instrument used to measure atmospheric pressure, was invented by Evangelista Torricelli in 1643 as an experimental setup: a narrow glass tube partially filled with mercury, with the upper end sealed and the lower end open and submerged in an open reservoir also filled with mercury. In this arrangement, the weight of the air column —that is, atmospheric pressure— determined the level of mercury in both the reservoir and the tube. When the pressure increased, mercury in the reservoir was pushed down, allowing some to rise inside the tube, causing the mercury column to ascend, and vice versa.

The use of this device as a practical measuring instrument emerged shortly afterward, when Blaise Pascal used it to measure pressure during his ascent of a mountain, confirming that it decreased with altitude. Meanwhile, Boyle and Hooke observed that it also varied with weather conditions, enabling short-term weather prediction.

This model belongs to the so-called "banjo barometers," named for their shape, reminiscent of the musical instrument. It is also a dial barometer and a siphon barometer —a direct descendant of Torricelli's barometer. It consists of a tube with a closed upper end, while the lower end forms a U-shape, with a second, much shorter branch open to the atmosphere and sensitive to air pressure, to which a system of counterweights and pulleys has been added. One of the weights floats on the mercury; as the pressure changes, the mercury rises or falls, moving the weight, which turns the pulley and transmits motion to the dial's indicator needle.

Banjo barometers appeared in the early 19th century, just as barometers were transitioning from purely meteorological instruments to highly prized and decorative objects

DIP NEEDLE

1900-1920

MUNCYT. DO 1995/031/0207
(DEPÓSITO DE LA FACULTAD DE CIENCIAS FÍSICAS, UNIVERSIDAD COMPLUTENSE DE MADRID)

A a dip needle, dip circle, dip compass or simply a device for measuring magnetic tilt, is precisely that: an instrument that measures the magnetic inclination at a specific location on the Earth's surface. But what is magnetic inclination? To understand it, one must start with the fact that the Earth behaves like a giant magnet, with two magnetic poles —the magnetic south pole and the magnetic north pole, the latter being the direction a traditional compass points to— and an associated magnetic field, evidenced by the existence of field lines running from one pole to the other. Magnetic inclination, therefore, is the angle formed by these magnetic field lines with respect to the Earth's surface. It ranges from 90° at the magnetic poles to 0° at the (magnetic) equator.

From this perspective, the design of the instrument makes perfect sense: a needle that, instead of rotating freely on a horizontal disc or housing as in a compass, moves along a vertical circle or semicircle, usually graduated and sometimes mounted on a support.

The utility of the instrument is equally clear: the angle indicated shows how close one is to the magnetic equator, whose exact location was, in fact, one of Humboldt's expedition objectives. At the same time, magnetic inclination at a known latitude provides clues about the nature of minerals in the soil, particularly their magnetism. If the measured inclination is greater than expected, it indicates the presence of another "magnet" nearby that is pulling on the needle.

The instrument on display consists of a graduated metal quadrant and a magnetized needle that can swing over the scale of the arc. To measure magnetic inclination, the graduated quadrant is aligned with the plane of the magnetic meridian —that is, the vertical plane running from one magnetic pole to the other. In this arrangement, the angle of the needle indicates the magnetic inclination at that location.

+INFO

GRAPHOMETER

Vicente Comas
1690-1770

MUNCYT. CE1992/014/0007

A graphometer is an instrument for measuring horizontal angles, widely used in surveying for creating maps and topographic surveys of land and estates. It is generally used in combination with a surveyor's chain or another instrument that allows distance measurement, although it can also be used independently to calculate distances through triangulation.

While some sources suggest it may have been invented by the Italian mathematician Niccolò Fontana Tartaglia in the first half of the 16th century, most attribute its invention —at least in its best-known form— to the French engineer, inventor, and engraver Philippe Danfrie in 1597, the year he published *Declaration de l'usage du Graphometre*. Its design remained more or less unchanged for the next three centuries, during which it enjoyed great popularity, although many later models incorporated compasses. This is the case with the instrument on display, made by the optical and scientific instrument maker Vicente Comás, who established his workshop in Barcelona in the first half of the 19th century.

In its most common form, the graphometer consists of a rigid semicircle with its corresponding diameter, each end fitted with a sight. Mounted on the semicircle, at its center, is a movable rule called the alidade, which can rotate along the diameter and is also equipped with two sights. The entire assembly rests on a support with a base. Its operation is fairly intuitive: once positioned horizontally on the ground with the alidade placed over the diameter, one sights a reference point through the four sights, then rotates the alidade until the second reference point is visible through its pair of sights. The angle is then read from the scale engraved on the semicircle.

From the 19th century onward, many graphometers replaced the traditional sights —simple slots in a metal plate— with telescopic sights, equipped with magnifying lenses that allowed for aiming at more distant objects, thus extending their range and improving precision.

HYPSOMETER

Graselli y Zambra
1860-1880

MUNCYT. CE1985/004/0761

A hypsometer is essentially a thermometer used to measure atmospheric pressure and/or altitude. But doesn't a thermometer measure temperature? Yes, but the hypsometer operates based on the so-called Thermometric Principle of Hydrometry, proposed by Fahrenheit in 1724 and experimentally verified by De Luc in 1762. According to this principle, the boiling point of liquids in general, and water in particular, decreases as pressure decreases: at atmospheric pressure, water boils at 100°C. A variation of 0.04°C in the boiling temperature indicated by the hypsometer's thermometer corresponds to a 1 millibar change in pressure. Or, equivalently, each degree change in boiling temperature represents a 27 millibar difference in pressure.

At the same time, atmospheric pressure decreases with altitude, as Pascal had already demonstrated in 1648. Therefore, both pressure and altitude can be determined by measuring the temperature at which a sample of water boils.

However, it took almost a century before the hypsometer was invented, presumably by the French scientist Victor Regnault around 1850. To fulfill its dual purpose, the hypsometer features, as expected, a thermometer enclosed within a tubular chimney. At the base of the chimney is a reservoir to hold the liquid, with a flame burner located just beneath it. When the liquid is heated to boiling, the released gases rise through the chimney and surround the thermometer, which registers the boiling temperature. Using reference tables, this temperature allows the determination of both atmospheric pressure and altitude.

There is more: at a known altitude and pressure, the boiling point of a liquid mixture can also provide information about its composition. For this reason, hypsometers —later renamed pycnometers— have been widely used in wine and other alcoholic beverage production facilities to determine alcohol content.

+INFO

SPYGLASS

By definition, all spyglasses are telescopes, but not all telescopes are spyglasses. Only refracting telescopes —those that use lenses in their optics— are considered spyglasses, in contrast to reflecting telescopes, which also incorporate mirrors.

This is a spyglass because it contains only four lenses in its tube: one in the objective, one in the middle section, and two in the eyepiece. These lenses are precisely the most remarkable feature of this instrument, as they constitute the achromatic system invented by John Dollond, who also manufactured this model.

In 1750, optics was embroiled in a debate between the opposing views of Isaac Newton and Leonhard Euler regarding the possibility of creating lenses that could eliminate chromatic aberration —the appearance of colored fringes around an image— by combining different types of lenses in telescopes. Newton had been the first to investigate this possibility and concluded that it was impossible. However, in 1747, Euler suggested that it was feasible. Dollond, as a true Briton, initially sided with Newton but decided to experiment with different lens combinations. This decision ultimately led him to invent the achromatic lens for telescopes. The design combined a concave lens made of flint glass with a convex lens made of crown glass, counteracting each other and thus eliminating chromatic aberration. He published the results in 1758 while simultaneously patenting his new achromatic lens, securing exclusive manufacturing rights.

From that moment on, Dollond telescopes and spyglasses —the only instruments equipped with his achromatic lens— became highly sought after and famous. From Frederick the Great to Thomas Jefferson, everyone wanted one. On his expedition to observe the transit of Venus in the Pacific, Captain Cook carried a Dollond spyglass on board, in addition to a Short reflector telescope. In fact, during the second half of the 18th century and part of the 19th century, the term "Dollond" became widely used as a synonym for telescope.

TELESCOPE

James Short
1755-1765

MUNCYT. CE1985/004/0165

Refracting spyglasses, or telescopes, were probably invented by the Dutch lens and eyeglass maker Hans Lippershey around 1600. However, reflecting telescopes —those that incorporate mirrors as part of their optics— were not invented until 1672 by Isaac Newton, when he replaced the usual lenses with concave mirrors inside the tube. The mirrors allowed for better focusing and avoided aberrations. They also improved magnification, since it is easier to manufacture a large concave mirror than an equivalent lens.

This portable telescope is a descendant of Newton's original design. As such, it contains two mirrors in addition to two lenses in the tube: near the eyepiece is a concave mirror with a central hole, and at the opposite end is another mirror of smaller diameter. When the objective is uncovered, light enters through the space between the tube and the mirror until it reaches the rear mirror, which reflects the rays onto the smaller mirror. This mirror further concentrates the rays and directs them through the hole in the first mirror to the eyepiece lens. Focusing is achieved using a rod at the bottom of the tube, which moves the mount of the smaller mirror via a screw.

As indicated by the inscription near the eyepiece —"JAMES SHORT LONDON 84/641 =18"— this instrument was made by the Scottish optician James Short, one of the most renowned makers of optical instruments of his time. The prestige and precision of his telescopes is evidenced by the fact that they were chosen to travel aboard the *HMS Endeavour,* commanded by James Cook, for observing the Transit of Venus from Tahiti in 1769.

The inscription also specifies that this is a telescope with an 18-inch focal length —specifically, instrument number 84 with this characteristic out of the 641 he had produced up to that date, a total that would eventually rise to 1,360 over the course of his career.

+INFO

MARINE CHRONOMETER

Ferdinand Berthoud
1787

MUSEO NAVAL DE MADRID. MNM1332

Between the 16th and 18th centuries, the development of an effective system for determining longitude at sea became the greatest challenge and objective of the European naval powers. In theory, it was a straightforward problem: knowing that there is a one-hour difference between two consecutive meridians, which are 15° apart, it would be enough to compare local time (on the ship) with the time at a reference meridian to calculate longitude. By then, pendulum clocks were already sufficiently accurate. The problem was that they became inaccurate due to the constant, irregular, and often extreme motion of the ship, as well as changing weather conditions, making it impossible to know the reference time.

The solution was not achieved until 1759, when after years of arduous work, the British clockmaker John Harrison built his H4 chronometer, capable of keeping time on board with an acceptable deviation of just 3 seconds per day. This was possible because it used a balance wheel regulated by a torsion spring, which was much less affected by the ship's motion and changing conditions than the weights and pendulums that regulated conventional clocks.

The H4, a marvel roughly the size of a large pocket watch, was presented to the Royal Society in 1760. A delegation of French horologists traveled to London to study it. Among them was Ferdinand Berthoud, who in 1775 built the first marine chronometer for the French Navy. Berthoud produced only 21 chronometers, including the eight commissioned by the Spanish Navy and delivered between 1775 and 1776, one of which is the piece on display in this exhibition.

It was during the second half of the 18th century that mass production of marine chronometers began. While in 1760 there were only four examples in the world (the H4 being Harrison's fourth prototype and the first fully operational), by 1815 there were over 5,000, and nearly all ocean-going ships carried at least one.

GEOLOGIST'S CASE

Around 1850

MUNCYT. CE1985/004/0213

Portable laboratories originated between the 17th and 18th centuries, driven by the great scientific expeditions of exploration and discovery, and by the growing interest in measuring, classifying, and analyzing the natural world and its phenomena.

These long expeditions could last several years, so the naturalists and scientists participating felt the need to carry all the necessary instruments with them, as Humboldt did. Moreover, they needed to equip themselves with a minimal portable laboratory —often in the form of a case or small suitcase— that could always be carried, containing the essentials for taking measurements and conducting analyses.

One of the pioneers in their use was probably Lavoisier, who in 1767 undertook a four-month horseback journey through the Vosges to classify minerals for the Atlas of Mineralogy, which he was preparing with Jan Guettard. For this purpose, he equipped himself with a small portable laboratory containing thermometers, a barometer, a hydrometer, and various reagents.

The use of these portable laboratories (and their name) spread and became common among scientists during the 18th century, standardized as cases or small suitcases containing basic reagents and small instruments. Johann Friedrich Göttling, a chemistry professor at the University of Jena, designed several models, the sale of which allowed him to supplement his salary, and they were very successful. It is therefore quite likely that one of Göttling's models was the one Humboldt took with him on his expedition, especially considering that he was already familiar with them, having begun his career as a mining inspector for the Prussian government.

The geologist's case on display is a perfect example of this type of portable laboratory, allowing a considerable amount of material to be carried in a compact space. It contains files, hammers, a Nicholson hydrometer for calculating densities or specific gravities, and a blowpipe for analyzing mineral samples and identifying their elements by comparison with standard samples contained in the glass containers.

THE INSTRUMENTS OF HUMBOLDT.
TOOLS FOR CONCEIVING A NEW VISION OF NATURE.

+INFO

CYANOMETER

Without a doubt, the cyanometer is one of the most poetic scientific instruments —if not the most poetic— since it is used to measure the degree or intensity of blue in the sky. This was an obsession for its inventor, the Swiss meteorologist Saussure, whose passion for nature had been instilled in him from a young age by his brother-in-law, the botanist Charles Bonnet. In fact, his fixation was not limited to the color blue; it extended to everything measurable in nature. And if there was no way to measure it, he invented a new instrument to achieve his goal. Thus, in addition to the hair hygrometer that bears his name, he invented a magnetometer, an anemometer, a heliometer to measure atmospheric warming from direct sunlight, and another instrument closely related to the cyanometer: the diaphanometer, which measured the transparency of the sky. In fact, the cyanometer and diaphanometer are so closely related that he invented both simultaneously in 1789.

The cyanometer is based on a design as effective as it is simple: a ring divided into 52 numbered segments, each dyed with a suspension of Prussian blue pigment in a different shade, ranging from white to black. To measure the degree of blue in the sky, one simply looks at the zenith from a specific distance from the eye through the ring and finds the segment that matches the color of the sky.

Why was determining the shade of blue so important to Saussure? Because he concluded that it depended on the atmospheric moisture content. The definitive explanation of the sky's color would be provided a century later by Lord Rayleigh, as a result of light scattering by atmospheric molecules and particles —including the tiny suspended water droplets that give the air its humidity.

Perhaps the greatest popularizer of the cyanometer was Humboldt —Prussian as the pigment itself— who made it one of his essential instruments. As a result, during his ascent of Chimborazo, he recorded a sky measuring 46 degrees of blue —the most intense ever documented.

NATURGEMÄLDE

Many may find it surprising —or even striking— that the *Naturgemälde* is included in this section. It shouldn't be: beyond being a beautifully and meticulously crafted illustration, the *Naturgemälde* is, above all, a scientific instrument. Or, if preferred, as noted in the exhibition's subtitle, it is a tool of great value and practical application for naturalists and scientists since the early 19th century, presenting a large amount of information in a completely new way —all on a single "plane." This approach allowed the data to be processed and interpreted in a novel manner, making it much easier and more evident to identify the relationships between different factors, their interdependence, and the consequences that arise from their combined effects.

Moreover, unlike some of the other instruments on display, the *Naturgemälde* cannot be considered an antique or obsolete tool, replaced by more modern or advanced equipment. On the contrary, it remains fully relevant to contemporary scientists: in 2015, a study analyzed the effects of climate change and consequent global warming, exemplified by changes in Chimborazo's vegetation over the past two centuries. The study compared the vegetation zones and conditions depicted by Humboldt in the original *Naturgemälde* with analogous representations based on conditions in 2012.

The study demonstrates the value and usefulness of these "paintings of nature" as scientific instruments, as a single glance at the comparison between the illustrations reveals the consequences of climate change.

A final note: it can be said that Humboldt's representations of nature are also precursors to modern infographics, understood as visual representations of information synthesized through the use of graphics and images. This approach is especially useful for conveying ideas or concepts, as visualization facilitates rapid understanding —yet another proof of the *Naturgemälde*'s enduring relevance and applicability.