

The Tagus River, the trams, the pavement drawings, the neighbourhoods, the fountains... Is it possible to explain the beauty of Lisbon? Perhaps not the beauty, but all the rest you can. This is the first in a series of guides that intends to take a scientific look at the city. Next titles:

2 Biodiversity in the City

Century-old trees, dragonflies, owls and bats. A look at the biodiversity of Lisbon.

3 Places of knowledge

The places and institutions related to the history of science in Lisbon.

4 Tastes of the City

Discover the physics and chemistry behind the pastéis de Belém or the traditional ginjinha.

5 Rocks and hills

How were the hills and valleys of Lisbon formed?

Pavilion of Knowledge — Ciência Viva

Situated in the Parque das Nações in Lisbon, the Pavilion of Knowledge – Ciência Viva is the largest interactive science and technology centre in Portugal. Great thematic exhibitions and hundreds of interactive exhibits encourage visitors of all ages to explore and experiment the physical world. Physics, mathematics, technology and other areas of knowledge are spread over an area of more than 11000m², where science joins up with emotion and the pleasure of discovery. Workshops, conferences and other activities make this place a house of science for everybody. Opening hours: Tuesday to Friday (10 p.m. – 6 p.m.), weekends and bank holidays (11 p.m. – 7 p.m.) Underground and train: Oriente Bus: No. 28.

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ASTRONOMY



SUNDIALS

Almost a century ago, the collective time for Lisbon residents was measured by sundials that were connected to small **pieces of artillery**. Around midday, when the sun reached its highest point in the sky, a lens focussed the light to set off a fuse, which in turn fired a gun. In this way, Lisbon residents were able to set their watches to solar time. There are still a few sundials in Lisbon, such as the vertical example on the cathedral. This had to be wedged in order to be correctly orientated towards south, allowing the hour-lines to be displayed symmetrically. The style (or **gnomon**) has the inclination of the latitude, being parallel to the Earth's axis. This allows it to measure the solar hours during the entire year. Another horizontal example can be found opposite the Jerónimos Monastery, and its gnomon is an anchor. Tram 28

ENGINEERING



THE GREAT EMBANKMENT

The Great Embankment, known as Aterro da Boa Vista, was **one of the largest public works** carried out by the Portuguese in the 19th Century. It immediately became a place for locals to take a stroll. Work was begun in 1855 on this construction that stretched from Cais do Sodré to Alcântara, which was a product of the land that was reclaimed from the river. The rocks used in the construction of the port are from local quarries, such as the fossil rich **miocenic limestones** from the quarries of Marvila. The old riverside path that went from Rua de S. Paulo to Calçada de Marquês de Abrantes is still reminded by the name of the street Escadinhas da Praia (Beach Stairs), in Santos. It was an area of swampy beaches and a series of epidemics that had spread through this area encouraged the great construction. Tram 15. Underground Cais do Sodré

GEOLOGY



LIOZ LIMESTONE

Churches, palaces, fountains, the Monastery of the Jerónimos and the Belém Tower, as well as the arcades at the Terreiro do Paço, Rossio Station and modern constructions like the Pavilion of Knowledge. Lisbon is a rare and beautiful micro-universe that showcases the use of a **rare stone** – lioz limestone. It is a type of compact limestone, with **abundant fossils**, that was formed around 97 million years ago (Cenomanian – Cretaceous) in an area of shallow sea with warm, clear water that stimulated the proliferation of organisms with calcium carbonate skeletons. Look carefully at its texture: the parts that look like pockmarks on first glance are actually pieces of fossilised shell belonging to organisms that lived millions of years ago. Underground Oriente

TECHNOLOGY



FUNICULARS

Lisbon is built on more than seven hills and the nature of the terrain has always made it difficult to access the city's high areas. The Lavra Funicular was the first to be built in 1884, linking the Av. da Liberdade to Campo de Santana, followed by the funiculars of Gloria (1885, linking the Av. da Liberdade to Bairro Alto) and Bica (1892, linking the riverside area to Bairro Alto). At first, all these funiculars used a rack-and-pinion and **water counterweight** system. Each car had a water tank that was filled on the top of the street and emptied on the bottom, in a way that the difference in weight made the system work. Frequent water shortages lead to the use of steam engines and, later, to the electrification of the systems. All the funiculars were designed by the Portuguese engineer **Raoul Mesnier du Ponsard**. Tram 28. Underground Baixa-Chiado

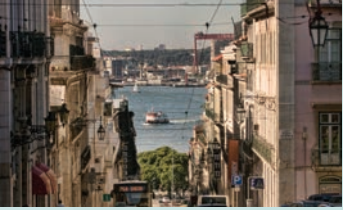
ASTRONOMY



LEGAL TIME

Do you want to set your watch? Set it by the Cais do Sodré. A long time before radio signals and satellite positioning systems (GPS), the ships that docked at the port of Lisbon relied on the time broadcasted from land for setting their on-board chronometers, with which they could calculate their **longitude at sea**. With the aim of displaying the Legal Time to the city and, specifically, to the ships anchored in the river, a clock tower was constructed in 1914 in Cais do Sodré. This tower was fitted with a mechanical clock, connected by electric cable to the Astronomical Observatory in Tapada da Ajuda. The tower was linked to a system that stretched along the coast as far as Belém, lighting up the time for any vessel anchored in the river. In 2009, a quartz clock was linked to the Observatory's network of **atomic clocks** through a Network Time Protocol (NTP), to guarantee the exactness of the Legal Time. Tram 28. Underground Cais do Sodré

METEOROLOGY



THE LIGHT OF LISBON

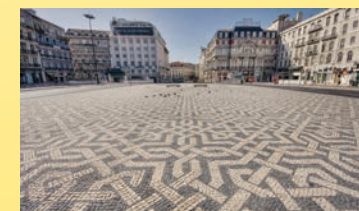
Poets, painters, locals and foreigners in general all feel the charm of the light of Lisbon. They feel, talk about and photograph it at all times of the day and in many different places. There are no scientific studies yet but, empirically, it can be said that, as the city is right next to the Atlantic, the north wind frequently sweeps away any pollution at the end of the afternoon, clearing the air. There is also the **immense body of water** lying at the city's feet – the river Tagus. When its water is calm, it reflects an immense amount of light. But the greatest **reflection effect** is caused by the houses with clear-coloured façades that are arranged in an amphitheatre shape. When and where is best to admire Lisbon's light? There are those who prefer the end of the afternoon, and those who believe that the magic has a greater effect at dawn, and many think that the best place to appreciate Lisbon's light is the other side of the river. Tram Baixa-Chiado

Guide 1

**IN LISBON:
DISCOVERING
SCIENCE AND
TECHNOLOGY
WANDERING
THE STREETS**



MATHEMATICS



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PORTUGUESE PAVING

Art and science literally right under your feet. Sidewalks, in Lisbon, are traditionally paved with small blocks of limestone, basalt and other materials. The pavers use moulds to mark the areas of different colours and they repeat these motifs in linear sequences (friezes) or in two dimensions (patterns). The geometry of the 20th Century proves that there is a limited number of **possible symmetries** in a plane: 7 for the friezes and 17 for the patterns. A project carried out by a group of young Portuguese students has documented 5 friezes and 11 patterns on the pavements of Lisbon, confirming the variety of symmetrical designs.

Underground **Restauradores**

GEOGRAPHY



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PRIME MERIDIAN

Along with other European nations, Portugal adopted Mean Solar Time at the beginning of the 19th Century (24-hour long days, when in fact the length of a day varies slightly by 16 min more or 14 min less during the course of the year). This simplified the definition of **Legal Time**. In 1878, the Lisbon Astronomical Observatory (OAL, created in 1861) began to function as the only prime meridian for the entire Portuguese territory. On 1912, after joining the Time Zone system, the Legal Time in Continental Portugal switched over to that of the Greenwich meridian. Clocks had to be put forward by 36 min and 44.68 s - the difference between the longitudes of the OAL and Greenwich meridians. But where is the old Portuguese prime meridian? Besides the OAL, this **imaginary line** passes through the old Cordoaria Nacional rope factory by the riverside.

Tram 15

URBANISM



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BAIXA POMBALINA

After the earthquake of 1755, the reconstruction of the so-called Baixa Pombalina neighbourhood took place. In this area of almost 23.5 ha, some of the technical improvements introduced were large, two-way streets arranged in blocks, the first public sewage network in the country and firewalls. The foundations are made of **pinewood props**, permanently submerged in the area's water table. A very innovative **anti-seismic construction** method known as the "Pombaline cage" was used to construct the upper floors of the new buildings. This system, the first of its kind in the world, was based on naval construction methods, and consists of an interior three-dimensional wood structure that is placed inside the brick walls to distribute seismic forces.

Underground **Terreiro do Paço**

ENVIRONMENT



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RIVER TAGUS ESTUARY

It is a surprising sight for most foreigners, but even the locals are not so used to seeing flamingos on the River Tagus. Its estuary is the **biggest of its kind in Western Europe**, with around 34 thousand hectares, and one of the most important areas of wetlands in Europe. It is a sanctuary for fish, molluscs, crustaceans and, above all, for more than 50,000 migrating water birds (flamingos, ducks, waders, etc.) that stop here during their migration between Northern Europe and Africa. The Tagus Estuary Natural Reserve was created in 1976 and protects an area of 14,560 hectares. Its symbol is the Pied Avocet (*Recurvirostra avosetta*), which name in Portuguese is alfaiate (**tailor**), due to the fact that it feeds itself by moving its thin, curved beak sideways through the sediment, as if it was trying to "sew it up".

Ferry boat **Cais do Sodré**

TECHNOLOGY



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TRAMS

The **yellow** tram cars which are able to navigate through narrow, steep and winding streets are one of the city's defining features. The tram system evolved from the "American" cars pulled by horses. In 1900 the aerial cables and new railroads were installed and the "**Geradora**" was built - a coal thermoelectric power plant that supplied energy to the entire system. The first tram line was launched in 1901, going from Cais do Sodré to Algés.

Tram 28

HYDRAULICS



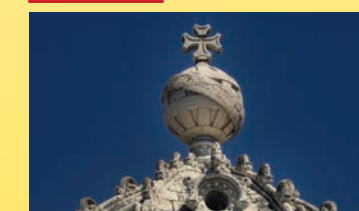
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FOUNTAINS

At first glance, the fact that Lisbon always suffered water shortages right up until the end of the 20th Century seems absurd, especially considering that it is right next to the river Tagus, but the effect of the tide is felt a long way up the river, making its water salty. Besides that, the whole city area **lacks sources of drinking water**. A new network of fountains was constructed from 1750 onwards after the inauguration of the Aqueduct of the Free Waters. An example of these is the Esperança Fountain, on Av. D. Carlos I, which has the peculiarity of separating the troughs for animals from the taps for humans in two levels, showing public health concerns. The water was distributed purely due to the **effect of gravity**, running through slightly inclined canals, without the use of pumps.

Tram 28

COSMOLOGY



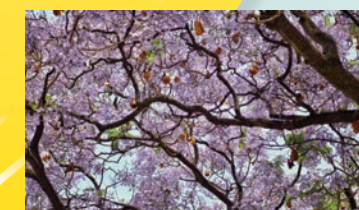
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ARMILLARY SPHERE

Found all over the city on historical and modern buildings alike, this image is a constant reminder of a certain Portugal. We refer to the Armillary Sphere, a sphere with rings that is used as a representation of the Universe. The Earth occupies the central position, according to the **Ptolemaic vision of the cosmos**. The main vertical rings represent the celestial meridians, the horizontal ones represent the equator, the tropics and the polar circles, and the zodiac band is set diagonally. In fact, the zodiac band (the line that traces the **apparent movement of the sun** through the sky, passing through the signs of the zodiac) should have an inclination of 23.5 degrees. However, either by mistake or aesthetic reasons, this band normally has a much higher inclination. They can be found over the Polytechnic School's gateways, in the Praça do Município, Monument to the Discoveries or Jerónimos Monastery.

Tram 15

BOTANY



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JACARANDÁS

There are those that take part in a sort of ritual every year to seek out the first blossoms of Jacaranda. The indigenous tupí-guaraní Brazilian name reveals the **exotic origins** of this South American tree. This deciduous tree can grow 15 metres high and its taproots grow deep without damaging the pavement. It flowers in May and June, although it can also happen at pretty much any time outside this season. An **explosion of violet** colours seems to sprinkle all over the city, adding "tropical flavour" to a Lisbon that is set between the Mediterranean and the Atlantic. They can be found in Campo Pequeno, the Eduardo VII Park, the Carmo Square and the Av. D. Carlos I.

Underground **Baixa-Chiado**

For more information about science
and technology in Lisbon, visit
www.pavconhecimento.pt

