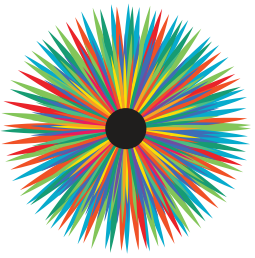
WHERE DID WE COME FROM?

WHO ARE WE?

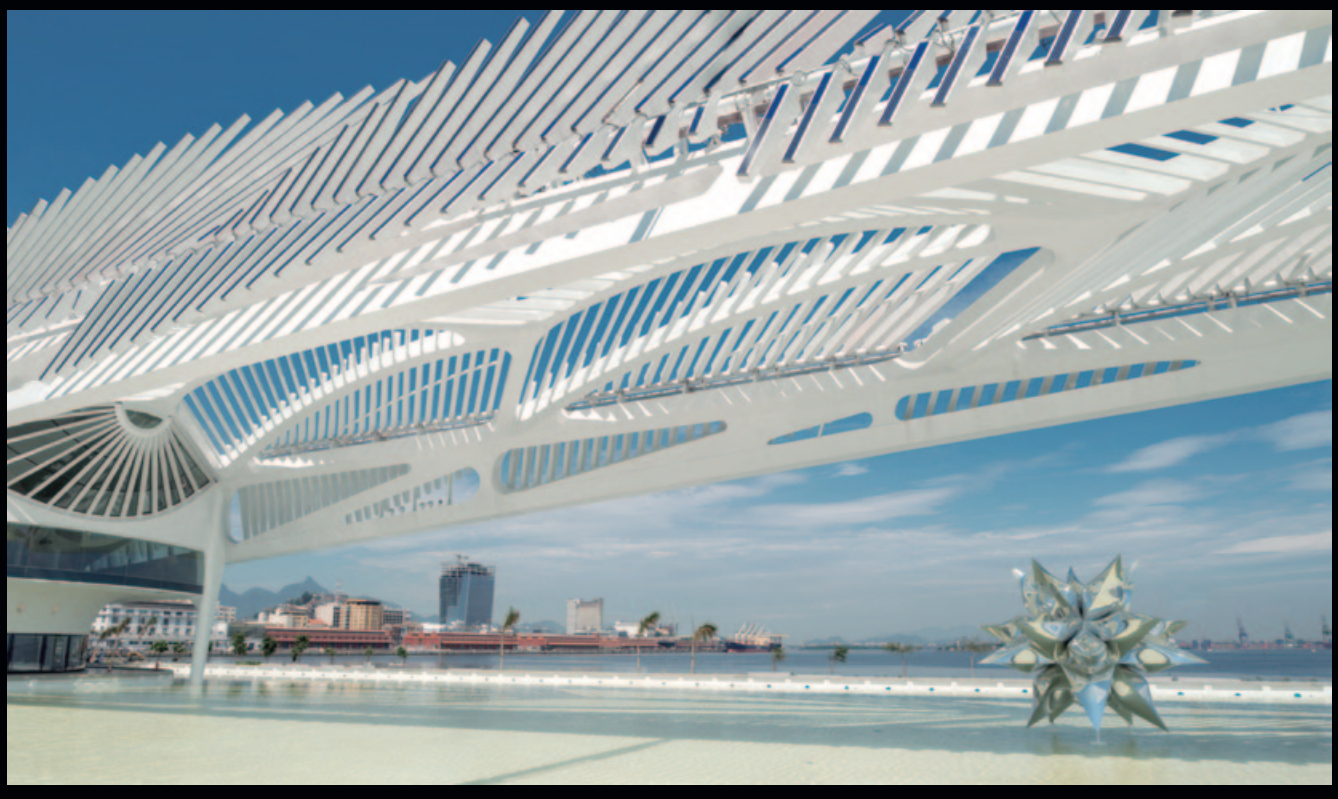


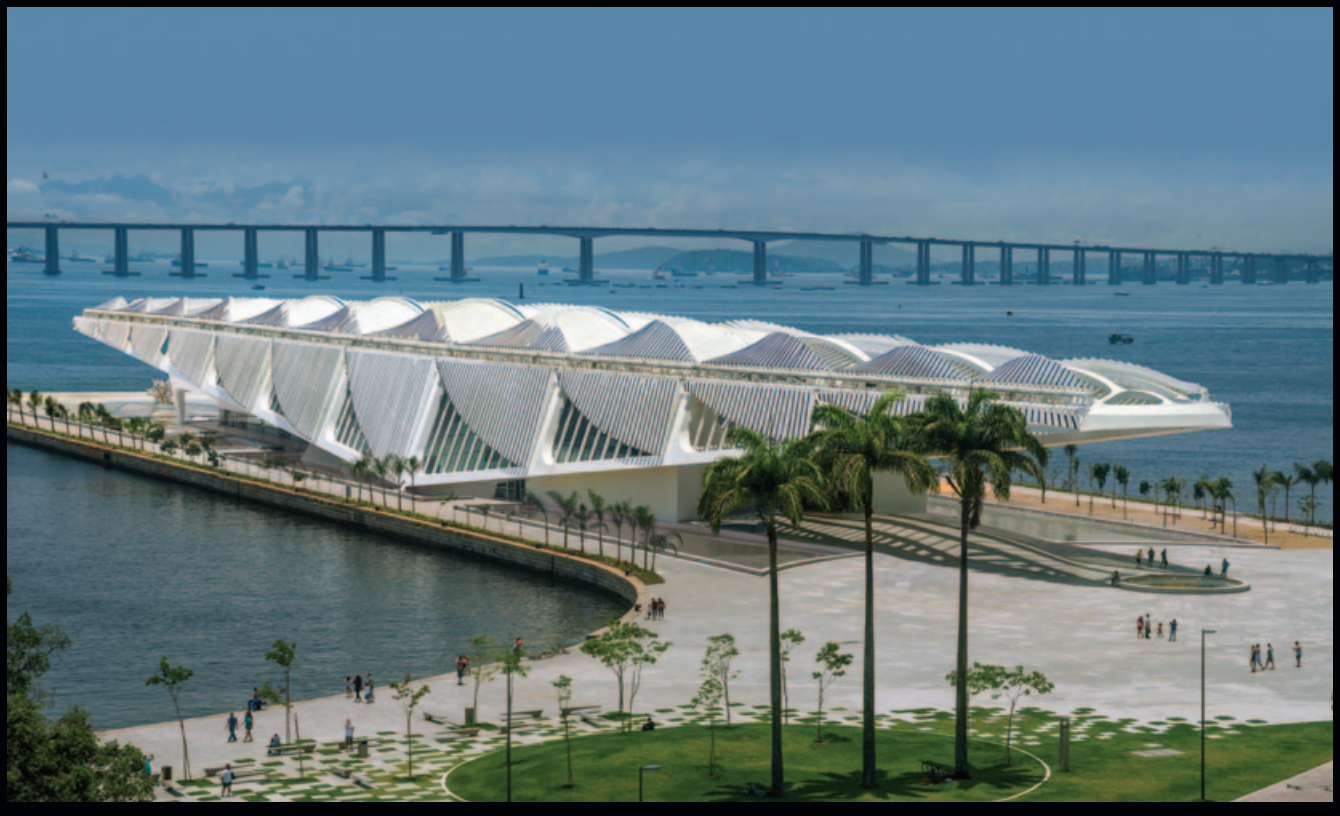
Museum of **Tomorrow**

WHERE ARE WE?

WHERE ARE WE GOING?

- HOW DO WE WANT TO PROCEED**?**





A MUSEUM FOR RIO AND ITS **NEW AGE**

Everyone who lands at a port – any port – has the awareness, if not the vision, that a future is about to unfold. They sense that this future is not something distant in time and abstract: it begins now, always at the moment in which one's feet, previously on the deck of a ship, in the uncertainty (and infinite possibilities) of the sea, touch the well-trodden stones of the quay, as in a famous samba song.

For many of the men and women who have arrived at the Port of Rio de Janeiro over time, the future and its possibilities often seemed uncertain. However, despite the inevitably unpromising setting, it was these men and women who to a large extent built the city of Rio and left a legacy of art, religion, science, culture – everything, in short, that human ingenuity is capable of creating.

One of the greatest legacies of the revitalization of Rio's port region is certainly the opportunity to reexamine this history. Today, thanks to the thorough archeological and historical work undertaken at the quay and in the surrounding area, we have a deeper and better understanding of the trajectory of a large share of Rio's population. We know it was the world's biggest entry port for African slaves, and as a result we are well aware of what tomorrow and its possibilities may represent. Above all, we recognize its creative and transformational power.

Like a ship docking at Pier Mauá, the Museum of Tomorrow continues in this manner of those landing at the quay: it thinks, dares, dreams, designs and sees different possibilities for the future. And it does so from the perspective of science. It is a museum of applied science based on the urgency of the present, encouraging reflection about the various possibilities of tomorrow. As a consequence, it provokes action to arrive at the tomorrow we want.

We now live in the Anthropocene Era: human action, whether individual or collective, generates impacts of geological dimensions on the planet. The Museum of Tomorrow is built upon this concept. With this awareness, we can understand how humanity got here and what futures are possible based on present actions.

Erected in an area with a historical vocation in the midst of an ambitious urban renewal process promoted by Rio de Janeiro's city government, the Museum of Tomorrow is part of a port zone transformed into a kind of nodal point, not just in terms of the transport network, but also driving the city forward: from how it has been so far toward what it intends to be. It is therefore a real place of connection between the past and future.

"The revitalization of the port region represents a recovery of our history. It is a city that looks to the future while preserving its past. The new Praça Mauá is self-explanatory, open, illuminated. The square is strengthened by the Rio Museum of Art (MAR) and the Museum of Tomorrow, promoting integration between Rio's residents, landscape, history, culture and leisure, set against the unique backdrop of Guanabara Bay, which gave birth to the city", says Rio's mayor, Eduardo Paes.

Originally designed to occupy two empty warehouses (numbers five and six), the plans for the Museum of Tomorrow changed when the city government proposed that the Roberto Marinho Foundation transfer its project to a new site: Pier Mauá. Not by chance, it is located across from MAR, forming a cultural arc that embraces the new renovated Praça Mauá.

"In an ever more urban world, one of humanity's great challenges is the way we occupy cities. The Museum of Tomorrow symbolizes the revitalization of an important part of the Port of Rio. Since construction work began, it has spurred reflection about what we expect of the city: a more integrated place with more generous public spaces", explains Mayor Paes.

The Roberto Marinho Foundation designed both museums, MAR and the Museum of Tomorrow, precisely to act as cultural anchors to revitalize the port region. Two of the main dimensions of human knowledge, art and science, are symbolically together in the efforts to regenerate a derelict area.

This is the profound sense that the Roberto Marinho Foundation places on an apparently simple task, to "make a museum." Making a museum in the Brazilian cultural context means looking at a site that needs to be recovered, thinking about the most suitable urban development and architectural proposal, choosing a theme and the best way to transform it into a contemporary narrative, ensuring its sustainability over time and in its relationships with the environment and community, and finally delivering a cultural facility that combines education with entertainment. Now that this complex project has been completed, the museum is opening its doors to fulfill the mission of all museums: to preserve and display a "muse." In the case of Museum of Tomorrow, this muse is our own shared tomorrow and the world we want to bequeath.

The Roberto Marinho Foundation's vocation to create museums has been developed in nearly 40 years of activity, initially dedicated to restoring built heritage and preserving colonial legacies. Little by little, the institution perceived that to best celebrate Brazilian culture, it was necessary to also work on non-material heritage. **"We found** that the best way to preserve was to give new life and add new content to these public buildings and monuments in the country, balancing material and non-material heritage, as seen in the establishment of the Museum of the Portuguese Language in Estação da Luz, a former train station in São Paulo", says José Roberto Marinho, the foundation's president.

The Museum of Tomorrow was created to be a living organism, in which multiple activities meet, associate and update themselves constantly, to guarantee a unique experience for each visitor.

In partnership with public and private institutions, the foundation designed the first museum in the world dedicated to a language, the Museum of the Portuguese Language. It celebrated soccer as a social phenomenon linked to the country's history and culture in the Museum of Soccer. Through Paço do Frevo, it paid tribute to the frevo rhythm, which is part of humanity's non-material heritage as a cultural manifestation deserving of a space to be celebrated the whole year and not just during carnival. It brought together art and education through the bold conception of a museum (MAR) with a school alongside it (or a school with a museum alongside it). And now, in addition to this Museum of Tomorrow, the foundation is preparing the Museum of Images and Sounds on Copacabana Beach, to celebrate Brazilian culture through the artistic creativity of Rio de Janeiro.

"The Roberto Marinho Foundation has designed and executed and the Globo Group has directly supported the implementation of some of Brazil's leading museums and cultural centers in recent years", says Roberto Irineu Marinho, the president of the Globo Group. "This demonstrates our love of Brazilian culture, which is in everything we do, including our everyday lives, in newspapers, radio, TV, internet, etc. On any platform, our connection with Brazilian culture is clear. In museums, this gains an even larger dimension, given that we have participated in designing, co-funding and divulgation work, at all stages of the process."

With regard to the Museum of Tomorrow, one of the assumptions was to develop a new, original science museum in Rio de Janeiro. "We can say that there are two generations of science museums", explains José Roberto Marinho, noting that the first is that of natural history museums, focused on the remains of the past. The second generation, whose most iconic examples are the La Villette Museum in Paris and CosmoCaixa in Barcelona, reproduces the phenomena of nature on a laboratory scale. "A third-generation museum would be constructed from a collection of possibilities. So, we thought: why don't we work on its approach to prospects for the future we desire for civilization, for relations between humans, and for relations between humans and nature? Our aim was to offer visitors ethical reflection about the tomorrow we want to build", he adds.

According to Hugo Barreto, the Roberto Marinho Foundation's general secretary, the Museum of Tomorrow is an invitation for reflection and transformation. "The symbiosis between MAR and the Museum of Tomorrow determines the regeneration of Praça Mauá and values the importance of this area, including the promenades created at the feet of São Bento Hill and along the sea. An environment is being formed that invites people to change their attitude to the city and those living in it. It calls for a shift in attitude in relation to the planet itself, or our own way of 'being' on it", notes Barreto.

The Roberto Marinho Foundation, whose model is to work in partnership with public and private institutions, joined with Rio de Janeiro city government to create this set of museums – MAR, which opened in 2013, and this Museum of Tomorrow, two years later. The project is also supported by the state and federal governments, on various levels.

Santander Bank and BG Brasil are the project's core private partners, providing not only financial resources, but also specialist knowledge and networks of relationships throughout the project's design, execution and sustainability work.

Inspired by bromeliads in Rio's Botanical Garden, Spanish architect Santiago Calatrava created a design in tune with the exuberance of the region's landscape and historical importance. "We took care to ensure that the museum was inserted in an organic way in the creative process of the city's formation and growth", says Lucia Basto, the Roberto Marinho Foundation's heritage and culture general manager, mentioning the two buildings she considers to be striking in the surrounding area: São Bento Monastery, declared a UNESCO World Heritage Site in 2014; and the building formerly occupied by the "A Noite" newspaper, in Praça Mauá, the first skyscraper in Latin America and the historic home of Rádio Nacional.

The singular character of Santiago Calatrava's design represented an engineering challenge. Although the concrete structure presents a certain symmetry, its curves are not repeated in the same way, and each component seems unique. With gardens designed to occupy an area along the museum and commissioned from the Burle Marx landscaping office, the architect aimed to recreate and integrate the outdoor space with a little of the Atlantic Forest. The 30,000 m2 external area includes gardens, reflecting pools, a bike path and an area for leisure.

Structured on two levels, adding up to a floor area of 15,000 m2, the Museum of Tomorrow hosts a main exhibition space in its upper part, with a ceiling height of 10 meters. The long-term exhibition is divided into five principal areas: Cosmos, Earth, Anthropocene, Tomorrows and Us. They result in more than 50 immersive, audiovisual experiences and interactive games, integrated with the Laboratory of Tomorrow's Activities, which brings together science, technology and art in a collective environment for experimentation, and the Observatory of Tomorrow, which through a system called a "Brain" receives data from scientific institutions across the world.

Like the other museums conceived by the Roberto Marinho Foundation and its partners, the Museum of Tomorrow was created to be a living organism, in which multiple activities meet, associate and update themselves constantly, to guarantee a unique experience for each visitor.

Attention to the environment was born together with the museum. The steel structure that covers the building features panels that capture solar energy and accompany the sun's movement; the reflecting pools next to the museum are part of a system that filters sea water to be used to cool the building, before returning it to the bay, now clean, in a small cascade at the end of the pier. "In this way we wanted to express a little of the desire to one day have a perfectly clean bay", explains Lucia Basto.

Due to its architecture, content and location, on the edge of the bay, the Museum of Tomorrow looks set to become a bridge between the city and the world, and between the city and its own tomorrow. From now on, people who land at the Port of Rio, coming from the uncertainties of the sea and stepping onto the quay, may not find certainties, but rather a space in which doubts about tomorrow may be converted into pure transformative energy. ●

The Museum of Tomorrow looks set to become a bridge between the city and the world, and between the city and its own tomorrow.

A SINGULAR MUSEUM IN SEARCH OF A **PLURAL FUTURE**

BY LUIZ ALBERTO OLIVEIRA

LUIZ ALBERTO OLIVEIRA is a physicist and the curator of the Museum of Tomorrow. He has a PhD in cosmology from the Brazilian Center for Physics Research (CBPF/MCTI), and he was formerly a researcher at the same institution's Institute of Cosmology, Relativity and Astrophysics (ICRA-BR), where he also worked as a professor of history and philosophy of science. He is a professor, speaker and consultant for various organizations.

We are all familiar with the image of the timeline, at least in the way it is generally presented in history books, encyclopedias or magazines. Along it, the great events and their most famous characters, the inventions and the geniuses who created them parade in a well-behaved manner. Along this line, as straight as a railroad, all the future has to do is advance – relentless and swift as a locomotive, this conventional symbol of progress in the imagination of the 19th century. There is nothing more comforting than the image of the future as a point somewhere ahead, fixed, waiting for us to become reality. Comforting – and illusory. Time, of course, is not a straight line. Nor is the future a fixed point: in fact, it is not yet anywhere. The central idea underpinning the narrative proposed by our museum is precisely that tomorrow is a work of construction and that this construction starts today.

It is also true that the Museum of Tomorrow has its own timeline, but the set of experiences it offers makes up a tortuous path like reality, unpredictable like life. The line of reflection we propose to visitors may be anything except straight. The line snakes around the past, present and more than a possible future. It descends to the bottom of the oceans and rises to the clouds, exploring the transformations in our climate. It penetrates between concrete materials, such as DNA structures and the circuits of electronic devices, but it also surrounds and envelops indescribable entities, like feelings and prejudices, fears and hopes, emotions and premonitions.

The conventional vision of time is also linked to an equally outdated vision of science. The scientific revolution triggered by the audacious theories of the likes of Einstein and Bohr began at the start of the 20th century. Since then, decisive experiments and devastating observations have ended up imploding the fundamentals of classical paradigms. Despite this, the consequences of this revolution begun a century ago have not yet been felt in the image that most people have of science. The vision of science as a set of finished truths is only gradually giving way to the understanding that it can only aspire to transitory knowledge, always prone to be updated and renewed. The answers are always partial. Fitting the last piece of the jigsaw puzzle means cutting out a new set of pieces.

To propose a new vision of time and tomorrow, and to stimulate another way of viewing science, there is nothing more appropriate than having a new type of museum. The Museum of Tomorrow was created as the anchor of a wide-ranging project to revitalize Rio de Janeiro's port area – the city's most ambitious urban intervention plan in the last 50 years. The initial, more modest proposal, to create a museum aimed at the issue of sustainability, installed in two of the port's old warehouses, ended up gaining a new dimension given the decision to commission Spain's Santiago Calatrava to produce a bold architectural design, to function as an icon for the renovation taking place throughout the area. The boldness of the Museum of Tomorrow, however, is not limited to its architectural lines. Its goal became to explore the idea that tomorrow is not a date on the calendar, nor an inevitable occurrence, nor a place we will reach: tomorrow is always a work in progress.

OBSERVATORY OF TOMORROW

Time does not stop, and nor does our museum. As an organism that aims to be not only living but also alert, we will constantly update the set of data used to produce the different items of content presented to the public. Whether a new photo taken by satellite, or the latest figures about the situation in the Cerrado (Brazilian savanna), or a new UN report about population, a specific sector of the museum, called the Observatory of Tomorrow, will receive and filter this data to ensure that the permanent exhibition displays up-to-date, rigorous information, exposed with clarity and in an interconnected way. Massive information technology resources, compatible with the needs of an almost entirely virtual facility, facilitate the absorption of this constant flow of data, images, graphics and numbers produced by entities such as NASA, Brazil's National Space Research Institute (INPE), the Intergovernmental Panel on Climate Change (IPCC), the World Resources Institute (WRI) and around 80 other institutions across the world with which the museum will maintain formal and permanent collaboration.

Besides managing this mass of information that will feed the museum's exhibition experiences, the Observatory of Tomorrow will also have some other functions. A mixture of editorial center and debate center, the Observatory will deploy this content, encouraging different sectors of academia and society to come together, above all to discuss topics related to the museum's two ethical pillars: sustainability and coexistence. Users will be able to join the Observatory to carry out research, interact with data through analyses and simulations, use spaces for meetings, and participate (including remotely) in seminars and series of talks given in our auditorium.

Part of a recent tradition of experiential museums, which feature interactivity – including the Museum of Soccer and Museum of the Portuguese Language, in São Paulo – the Museum of Tomorrow also shares an affinity with the generation of science museums that spread around the world in the last two or three decades. Whereas the first generation of natural science museums worked with physical collections made up of relics, fossils, fragments and artifacts, at a subsequent moment the intention changed from being merely to offer information to visitors or even the mere enjoyment of a collection, as happens in traditional fine art museums. Instead, science museums started to try to demonstrate in what way things worked. What are the laws of nature? How do objects fall? How do electrical currents light up bulbs? Such demonstrative museums set out to present phenomena and explain the rules according to which they work.

On this journey, the Museum of Tomorrow aims to take an extra step, going beyond contemplation and interactivity. Our objective has been to create a museum of applied science. More than just showing how science works and how scientists work, describe laws and make their discoveries, our goal is to use the resources that science has developed in recent times to invite visitors to explore possible paths for the future.

Whereas old natural science museums were organized around a collection of objects and dead specimens, the Museum of Tomorrow's core archives are made up of possibilities. Before, there were vestiges of the past; now, there are possible futures. Accordingly, it is a completely original museum. Two complementary characteristics stand out in its concept. Besides offering an entirely non-material experience, namely possible tomorrows, it is also a museum that is clearly engaged with a figure of time: the figure of tomorrow.

To take account of a science that is a set of transitory knowledge in constant transformation and be able to probe a tomorrow composed of possible futures, it is vital for the museum's content to be continually updated. Prospects, forecasts and estimates, in different fields of nature and human activity, will always be updated from the perspective of the next 50 years. Hence the choice to make the museum completely digital, allowing visitors to have the experience of something that is immaterial, something in the realm of the possible. Except for a few physical objects, everything else in the museum is virtual.

The museum's conceptual foundation is the understanding that tomorrow is not the future. Because while the future is something that is already there, tomorrow is here, and it is always happening. And this construction will be made by visitors, people, citizens, the people of Rio, Brazilians, members of the human species.

The objective is to construct a sequence of experiences in which visitors can gradually acquire the means and resources to live out the possibilities of tomorrow that are opening up today. Ultimately, what the museum intends to offer is an experience of causalities. To talk about the future in other terms, we need to resort not to the straight line, but the image of the maze, which is so dear to Argentinean writer Jorge Luis Borges. According to the author of the tale "The Garden of Forking Paths", far from being a spatial trap that does not lead anywhere, the maze has its fundamental unity at its crossroads. Which paths will we take? Which doors will we open? The choice is imponderable. With every path we follow or door we open, the die of chance rolls on the table of necessity. A maze is a matrix of futures.

To guide us in this labyrinth, we have something more than mere chance: applied science offers us resources to find out that each decision we take will correspond to a consequence. And this, in turn, will cast its shadow on us and future generations. If we choose certain actions, certain scenarios will become more likely. If different actions are taken, other tomorrows will be favored. Our old straight line, made sinuous like a river, sprouts from a single "today" into smaller paths, forming a delta of possible tomorrows. This is the idea the museum aims to explore.

To this end, we have constituted a narrative involving different dimensions. We chose to embody each of the moments in this journey through specific exhibition design, decoration and resources. In other words, out of a total of five areas, each of them conforms to a certain kind of spatial experience, or sharing, of movement and paths. This main exhibition of the museum, a journey composed of different stages, adapts to the space designed by Calatrava, like a large cathedral nave. The five moments of this journey roughly coincide with the ambiences defined by the shapes of the building's ceiling.

There are two more direct ways of conceiving of the visit stages. One of them consists of associating the dimensions with figures of time, while the other involves linking them with questions. All the museum's content, synthesized in over 50 different experiences, linked and distributed across these five areas, is designed to address major questions that humanity has always asked. The idea is for visitors to explore this sequence of questions.

In the first stage, which we call "Cosmos", the question to be proposed is "Where did we come from?" and the figure of time is "Always." After this comes "Earth", which seeks to address the question "Who are we?" while evoking the time figure of "Yesterday." In the space we call "Anthropocene", the question is "Where are we?" and the time unit is "Today." In the "Tomorrows" space, we sought to explore the question "Where are we going?" Finally, the journey ends in the "Us" space, in which we pose the question "How do we want to proceed?" – in other words, with what values do we intend to continue ahead?

Our goal is for people to be snatched away from their everyday life, from their habitual ways of thinking, from their usual places, to experience something they do not find at home, in the street or on the internet. Something different, which they will only experience here. The content is transmitted through experiences, like one of those offered in the first stage, which resolves around the question "Where did we come from?" In it, visitors will find themselves immersed within a 360-degree projection of a dome, crossing galaxies, the heart of atoms and inside the Sun. They will watch the formation of Earth and the development of life and thought, manifested through art. The idea is for visitors to be able to learn about dimensions of our natural existence they are not used to experiencing without resorting to scientific instruments. From the micro to the macro, from astronomical dimensions to subatomic dimensions. It is a sensory, poetic, motivational experience, which prepares us to see the Cosmos as an evolutionary totality, which far exceeds us, embraces us and constitutes us.

FROM THE IRIS TO THE BRAIN

Upon entering the Museum of Tomorrow, each visitor will receive a card featuring a chip. They can use this to identify themselves by providing their email address and, if they wish, their name. When they come across one of the interactive posts distributed throughout the main nave, they will make contact with IRIS, a program that personifies the content generated by the group of consultants who have contributed to the museum and which has the capacity to identify and engage in dialogue with each of the visitors. For example, when connecting during a subsequent visit to the museum, IRIS will know which sectors or areas the person visited the last time, or which activities they took part in, and it will be able to then suggest new routes to explore or recommend content that may be accessed during their latest visit. IRIS will also be able to provide visitors with information or data updates via the internet.

IRIS is part of the museum's system, called the BRAIN, which is capable of storing, permitting analysis of, and distributing the mass of information associated with the content on display. Its multiple, parallel functions include recording visitor flows. The software developed for it will make it possible, in real time, to determine the most accessed content and visitors' characteristics. In this way, it is as if the museum had the capacity to accompany a little of its own metabolism, counting on an image of itself even as it functions.

The second moment is Earth, associated with the question "Who are we?" and also the dimension of "Yesterday." The experiences and information in this space will confront us with the fact that we are earthlings. We are combinations of matter, life and thought, represented in this stage by three large cubes. Far from being watertight, these three dimensions interact with one another. And the unique factor is that thought has the capacity to reflect on its organic bases, investigate its material supports and embrace the Cosmos itself from which we came. We know today that we are part of the Cosmos, and precisely for this reason, it is part of us.

All the cubes will have both external and internal content. In Matter, for example, from the outside visitors will have a unified vision of Earth, like the one seen by Russian cosmonaut Yuri Gagarin. It will not be presented fragmented into countries or continents, but as a single entity. In this experience, visitors will see around 180 very large photos of Earth. And inside the cube, they will encounter the different rhythms that mark the planet's material functioning: different flows which in metaphorical terms we call "oceans." The very slow movements of tectonic plates (in some cases a few centimeters a year), the faster motions of ocean currents (tens of kilometers per hour), the much faster movements of the winds through the air, and the extremely rapid movements of light from the Sun. These four rhythms are associated to produce a new one – the rhythm of climate and the succession of the seasons.

After this, we have the cube of Life, whose "skin" refers to the biochemical support of the basic code that governs the composition and development of all living beings, DNA; the inside presents the immense variety of organisms, which interact in multiple ways, forming ecosystems. We will present the ecosystem of Guanabara Bay, where the museum is located, in its different strata, from the top of the Órgãos Mountains to the coastal mangroves, and we will also show the microbial ecosystem that each of us hosts, and on which our health depends.

The third cube then presents the dimension of Thought. On the outside, we once again have a unifying element: our nervous system, which is essentially the same in all human brings. This fundamental identity, however, results in an incredible diversity of cultures, illustrated by hundreds of images portraying different aspects of our life, feelings and actions – how we live, celebrate, have conflicts and belong.

The following stage is the central moment: both spatially, as it is halfway through the itinerary, and in conceptual terms, as it discusses our condition and that of the planet. Anthropocene is a term coined by Paul Crutzen, a joint winner of the 1995 Nobel Prize in Chemistry. The Greek prefix "anthrop" means human, while the suffix "cene" denotes the geological eras. This is therefore the moment in which we find ourselves: the Age of Humans. This is the age in which *Homo sapiens* has noted that civilization has become a force with a planetary reach and geological duration and scope. In a very rapid process, we went from a few thousand individuals roughly 70,000 years, when we started to spread across the planet, to 7 billion people. From a biological point of view, this growth is equivalent to that of a colony of bacteria: an extremely explosive rhythm in a very short period. We have spread throughout the planet: today there is not a single region that has not been directly or indirectly affected by human activity as a whole. The question to be explored is: "Where are we?" and the time is "Today."

To physically mark this awareness regarding this "today", we have erected something like a large monument, inspired by the standing stones of Stonehenge, England. Through this, we wanted to highlight the consequences of human activity. There are six standing stones, 10 meters high and 3.5 meters wide, bathed in light. This was the visual way we found to announce, with no room for doubt: it is here where we find ourselves, in the Anthropocene. Four of these standing stones feature caves, in which visitors can explore around and look for more information, more evidence about people's spread across the planet and the better understanding we have today about this process. This is the core experience of the Museum of Tomorrow.

If we consider that in a single century we have changed the pattern of sedimentation in all the world's river basins, on all the continents; that we have changed the atmosphere's composition, because we have been consuming fossil fuels for three centuries in a kind of continuous fire; that we are drastically interfering with the distribution of life and Earth's biomes; that we are changing climate patterns... Taking all this into account, the geologists of the future who examine our era will find traces and evidence that a new agent gained a planetary reach and affected Earth in this geological period. This agent is humanity.

Hence the power of the term Anthropocene: it signals that we are in a new geological era, the era in which human action affects all the planet's domains. And, of course, it affects the continuity of humanity itself. This is the moment when human actions necessarily bring about consequences for their own author. This is a characteristic of a certain type of natural system, which we call complex systems. Their behavior is not linear because actions triggered by this agent affect itself and modify its own nature.

Henceforth we will no longer live on the planet inhabited by our ancestors. Over the course of whole eras, Earth was frozen; in others, it became infernally hot. There were then various moments in which Earth was a very unfavorable environment to host a civilization. Over the past 15,000 years, on the other hand, following the last great thaw, Earth has been a much more welcoming planet. However, we are now set to live on a different planet, profoundly modified by our own actions. This is the decisive understanding that the museum aims to offer its visitors. This understanding, which marks "Today", will shape the options faced by humanity.

LANGUAGES FOR ALL AUDIENCES

Making new generations start to rethink their relationship with time and the planet is one of the Museum of Tomorrow's biggest challenges. Children, even those not completely familiar with writing, now make up a significant part of museum audiences throughout the world. Working with content with various levels of complexity but without reducing the quality of information, the museum has decided to complement its proposed journey with a series of activities and experiences.

"Tomorrows" are the next moment in the journey, defined by the question "Where are we going?" The simulations, estimates and projections associated with this stage are provided in a work of origami. Three areas are demarcated in it, presenting six trends that will shape the future over the coming decades. The demarcated areas concern respect for living together (society), living (planet) and being (people). The six trends are climate change, about which there are no more doubts; the rise in the world's population of around 3 billion people in the next 50 years; integration and differentiation of peoples, regions and individuals; alterations to biomes; the increase in the number, capacity and variety of artifacts produced by us; and finally the trend for the expansion of knowledge.

Each one of these trends promises to profoundly alter our lives in their most everyday sense, always confronting us with political issues and ethical choices. The overwhelming majority of these 3 billion new inhabitants of the planet will be added to the population of the tropical belt, where the globe's poorest countries are found. Alongside environmental issues, inequality will be one of the main challenges humanity must face together. As well as more numerous, we will also be longer-lived: in a decisive biological fact, every five years during the 20th century we gained one year of life expectancy. In a century, we gained 25 years. Having grandparents in our family who are present and active is now commonplace, but for most of human history they were rare figures. This extension of longevity and the large number of elderly people it implies will oblige us to face a new reality with regard to the labor market, and our entire understanding of how to organize our productive life will have to be modified.

Other trends will confront us with equally challenging dilemmas. If in an ever more interconnected world, the conditions for the emergence of a planetary, urbanized culture, structured around megacities are established today, this context, on the other hand, will probably lead to a reaction from those who prefer to retreat to their own culture. How will we administer these tensions? How will we manage cities of 40 million or more inhabitants? The impacts on biomes will also have effects on the economy that we have barely started to assess. The current trend toward the miniaturization of electronic components is irreversible: for example, the circuits of the devices we now carry about in our pockets soon may be tattooed on our skin – this idea has already been patented – and their chips directly integrated into our nervous system. And the acquisition of knowledge is today on a very steep curve: the quantity of data we have access to about various fields of knowledge has been accumulating exponentially. For example, specialists say that roughly every three years, the amount of available data about chemistry doubles.

Based on these trends, visitors will be able to view different future scenarios, each one being the likely consequence of a given course of action we are adopting today. We decided to set out the framework of possible perspectives in order to take a realistic stance, avoiding both a naive optimism and a catastrophic vision, which would make human intervention irrelevant. On the contrary, we believe that, in the midst of this vast web made up of causes and consequences, there are many open-ended alternatives, and that they can be glimpsed from contributions by the specialists who have contributed to the content presented by the museum.

Without forgetting that our central character is humanity, we sought to present these alternatives and possibilities from a historical perspective, through games, including a Games of Civilizations, based on a model studied by NASA. Examining examples from the past, such as the experiences of the Han civilization in China, the Mayans or the Vikings, it is possible to interpret the evolution of civilizations based on variables such as resource consumption, population size and inequality. In the game, we have the power to control certain parameters in order to make a civilization continue or wither away.

The last stage of the journey is "We", structured around the environment of a hut, symbolizing an indigenous house of knowledge, in which family members and tribal clans gather and the elders repeat to the youngers the legends, narratives and stories that make up the foundations of their culture. After experiencing the vastness and variety of the Cosmos, and information and experiences regarding the dilemmas we are facing, this is the moment when we turn inward a little, to reflect on how we want to live with the world (for the sake of sustainability) and with others (for coexistence). Here the emphasis is not on information, but rather the values we offer for visitors to ponder.

It is in this space that visitors also encounter one of the few physical objects in the museum's collection: a churinga. This Australian indigenous people's artifact, of enigmatic appearance to us, is in fact a tool. However, it is not designed to drill or cut: it is a symbolic utensil. For the people who created it, it was a temporal tool, to associate the past with the future. Upon dying, a member of the community had their soul conserved in the churinga, where it remained until it could reincarnate in another member of the group. The churinga thereby represents the very continuity of the people and their culture. Through mysterious paths and chance occurrences, this slender carved wooden object left the arid Australian desert at some moment in the 19th century only to land at the pier of Praça Mauá in the 21st century. Curiously, its basic design is quite similar to the museum's shape conceived by architect Santiago Calatrava. Coincidence, destiny, shape: everything therefore conspires to make it a highly appropriate symbol of the mission proposed by the Museum of Tomorrow: to connect the present, past and future. ●

LABORATORY OF TOMORROW'S ACTIVITIES

Platform for transdisciplinary experimentation and the exhibition of innovative projects.

The Museum of Tomorrow has an area specially dedicated to innovation and experimentation: the Laboratory of Tomorrow's Activities. Its mission is to help the museum remain alive, in a process of permanent reinvention.

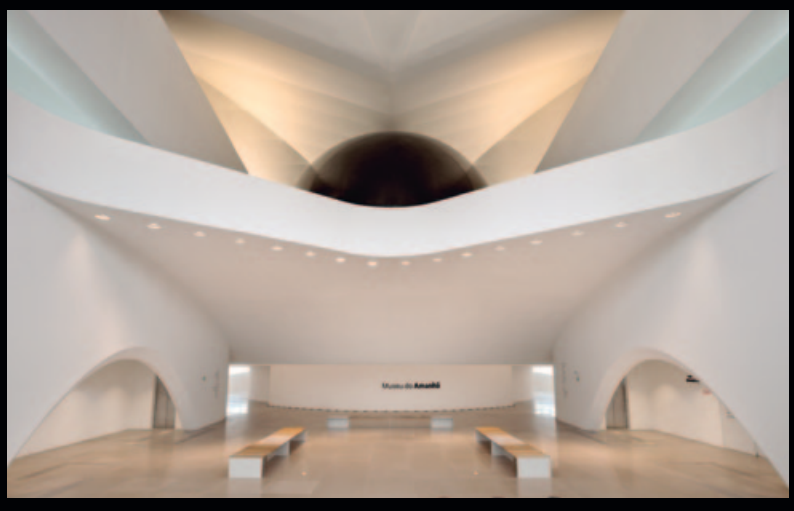
A space for transdisciplinary art, science and technology meetings, the laboratory will promote the introduction and adoption of new tools, new processes, and innovative ideas and initiatives. It will stimulate the public to stop simply being consumers and to become creators, as beings capable of producing prototypes for high-impact solutions for their life and the world, and thereby invent possible futures. Creating a bridge between thinking and doing, between imagining and implementing, the Laboratory of Tomorrow's Activities will explore opportunities and challenges in a universe of continuous and ever more accentuated changes.

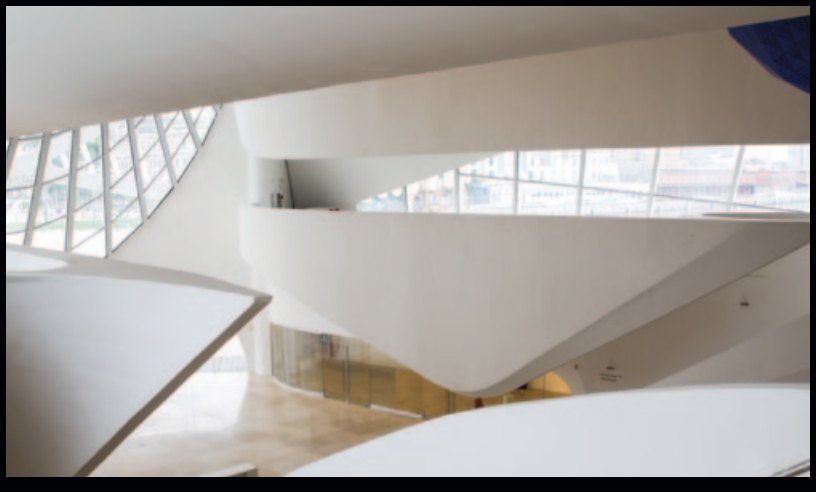
The laboratory possesses a space for collective production and experimentation, containing a variety of resources and equipment to support creative work, and an environment for exhibitions, presenting projects and displaying prototypes. It will also take over locations inside and outside the museum as expanded developments of its program of activities.

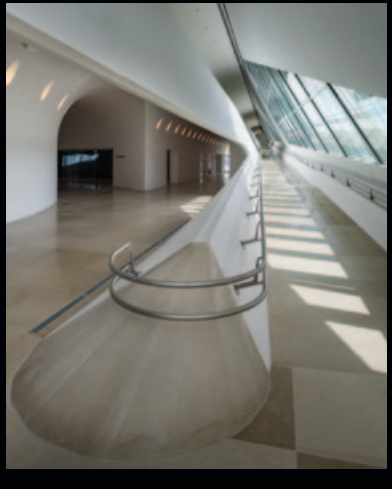
Entrepreneurship, the impact of "exponential technologies" – such as artificial intelligence, the Internet of Things, robotics, genomics, 3D printing, nanotechnology and biotechnology – and the exploration of future scenarios are the laboratory's core themes. It will operate in four areas: education (courses and workshops), activities (creative sessions and "citizen science" projects, among other things), a creative residency program, and exhibitions.

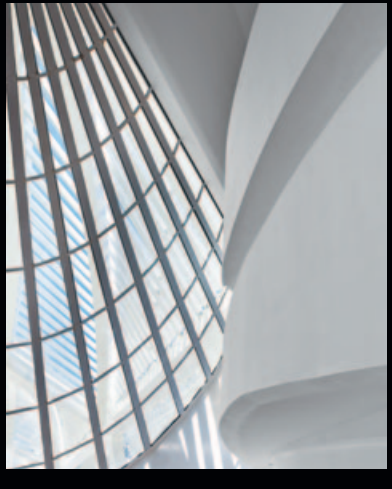
Welcome to this journey
of science, experiences
and possibilities.
And remember:
somewhere, at this
exact moment,
day is breaking.
Dawn always
returns, it is always
the same, and yet
every time it is
always different.

TOMORROW BEGINS **TODAY.**





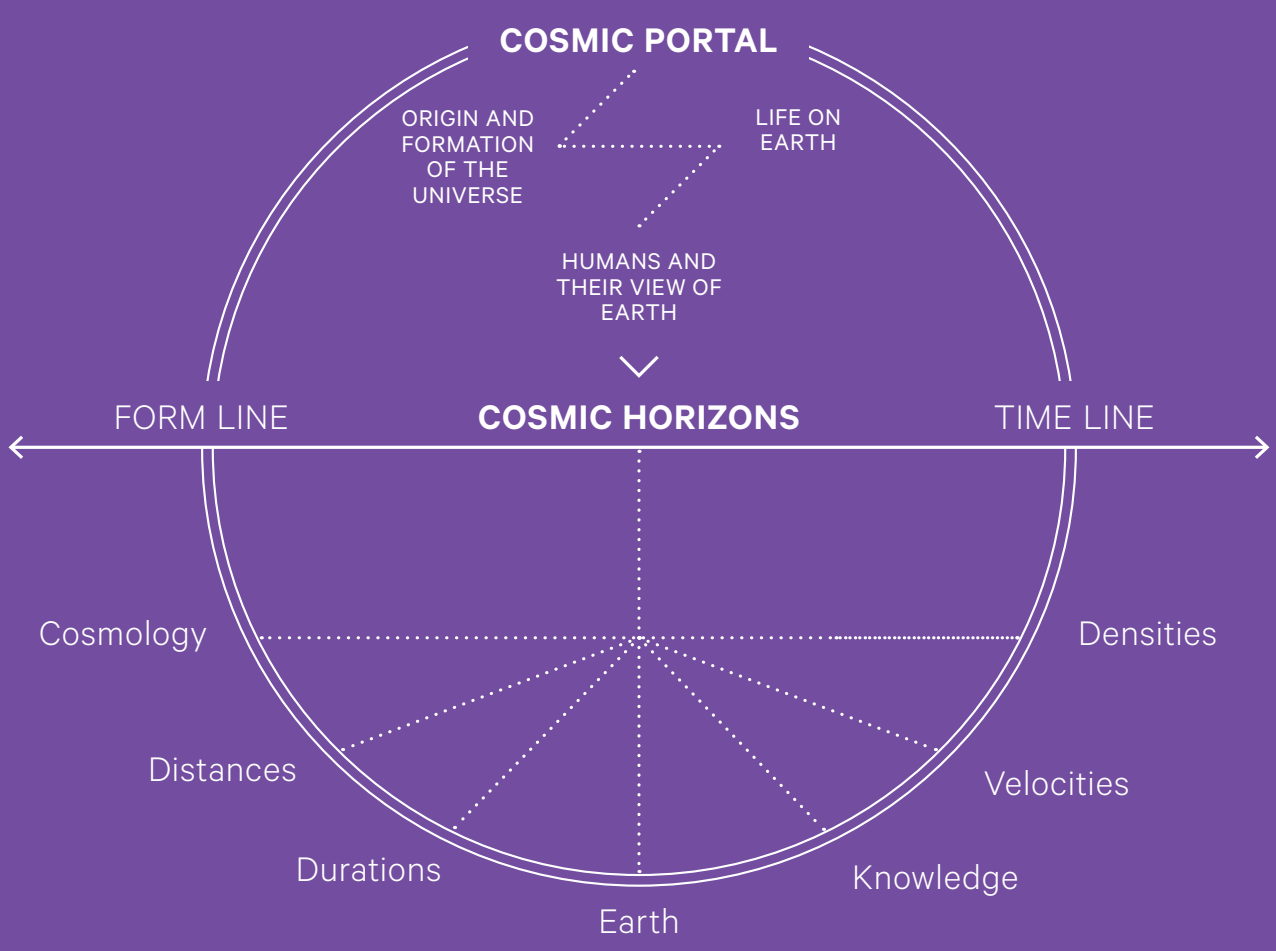




ALWAYS

Cosmos

WHERE HAVE WE COME FROM?



The starting point of the museum but also of a journey that does not have a beginning or end: the Universe is both our origin and our destiny.
From the largest scale to the most minute, from subatomic to astronomical dimensions, the Cosmos covers us, forms us and surpasses us: we inhabit it and it is in us. Understanding this dual belonging, exterior and interior, serves as a gateway for us to embark on the journey proposed by the Museum of Tomorrow. The advances of science offer us an increasingly clear vision of our place in the Universe and of the moment of its evolution in which we find ourselves. This new global context of our existence requires very different durations, distances, speeds and densities from what we are used to on Earth.
A poetic and sensory experience, visitors will be invited to explore the 13.7 billion year existence of the Cosmos through a projection on a 360 degree dome, traveling amongst clusters of galaxies and diving through atomic nuclei, witnessing the formation of the Solar System, the emergence of life and thought symbolized by art. Our dilemmas and choices are seen from a new perspective, one where human history is rooted in the long history of life, and which, in turn, rests on the immense history of the Cosmos itself.

THE COSMOS, A UNIVERSE OF POSSIBILITIES

BY ALEXANDRE CHERMAN

What is the Universe? Where did it come from and where is it going? These ancient questions that accompany mankind already have an arsenal of answers given by theology and philosophy and have been tested in many other fields of knowledge.

There is, however, a path that seeks to understand this field and that is of particular interest to us: physics. Originally conceived in Ancient Greece as "the science of nature", physics by definition dedicates itself to the not insignificant task of "investigating the laws of the Universe with respect to matter and energy, which are its constituents, and their interactions"[1]

Ernest Rutherford, the man who discovered the atomic nucleus, once said: "There are only two kinds of science:. physics and philately"[2] He called attention to the predominantly explanatory nature of physics, trying (albeit in and arrogant and somewhat unfortunate way) to show that all strands of science at some point use physics to make progress with their findings.

Astronomy, for example, by separating stars in colors, is philately. But it is only from the understanding of how they work, how they generate energy and how this energy is distributed on its surface that we can understand the 'why' of colors - and that is physics. The same goes for geology and rocks, oceanography and currents, meteorology and weather patterns, engineering, medicine and biology. Hand in hand with astronomy, and not forgetting philosophy, physics studies the Universe and attempts to answer three fundamental questions: Where have we come from? (our origin in the past); Who are we? (Our permanence in the present); and Where are we going? (our existence in the future). For this, it has created a new branch within it: Cosmology, or the study of the Cosmos.

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1 *Houaiss dictionary of the Portuguese Language*, Rio de Janeiro: Objetiva, 2001. 2 .B. Birks (org.), *Rutherford at Manchester*, Londres: Heywood & Co., 1962.

And what is this term coined by Pythagoras, the Cosmos? In its original context the Greek mathematician recognized the existence of a celestial order intrinsic to the sky around him. For him order is the source of beauty, and this "total organization" which he named "Cosmos" (or κόσμος, in the original Greek - a word that is also the root of "cosmetic") was "the most beautiful of the bodies ".[3] This name, however, would only enter into our current vocabulary with the work of noted German geographer Alexander von Humboldt, who used the borrowed term to baptize his greatest work in the 19th century.[4]

The term "Universe", which we use daily as a synonym of Cosmos, was in fact born out of a conceptual error. Originally from the Latin unus verterem, "that which rotates as one", today the word does not represent the movement that defines the Universe - because it definitely does not rotate as one. It was a clear allusion to the pre-copernican conception in which the Earth was seen as a stationary star in the center of the cosmos, with everything else turning in unison around it.

With the old definitions out of date we return to the question: what can ultimately be understood as the Universe? The answer is simple: it is all that exists, it is the most comprehensive expression of natural existence. In its simplicity this definition has a mixture of clarity and obscurity, it is attractive and mysterious and does not require well-defined borders. If we accept that the Universe is all there is - and that we include all things in it such as objects, dimensions, realities, and everything that we may not even be able to suspect that exists - , then there is nothing more ambitious than to study it.

Our definition can be even bolder if we say that the Universe is not just all there is, but also what existed and will exist. Hereby we incorporate temporal divisions within it, yesterday, today and tomorrow, returning to the questions that have plagued mankind since the beggining of time "Where have we come from?"; "Who are we?"; and "Where are we going?".

Where have we come from? How was the Universe in the past? Is there an infinite past? Or did everything arise from a particular point in time?

The last two questions can be frightening and it is up to each one of us to choose the most comforting response: has the Universe existed for ever or did it emerge from a particular point in time?

Behind the first response we find infinity: the Universe has always existed. In this case our finite brains, transitory and ephemeral, may not be able to deal with the concept. How can we conceive of something that does not have a beginning?

Behind the second response is spontaneity: the Universe began at a certain point in time. In this case the question is how to deal with the fact that everything that exists, has existed or will exist was created out of "nothing."

We can say that there are different types of infinite as, even though the Universe of the distant past can also be defined as infinite, it has been increasing in size. In other words, the infinite of today is obviously greater than the infinite of the past.

3 William Smith, *Dictionary of Greek and Roman Biogra- phy and Mythology*, Boston: Little, 1870. 4 Alexander Von Humboldt, *Cosmos: A Sketch of a Physical Description of the Universe*, trad. E.O. Otté, Nova York: Harper & Brothers, 1860.

Modern science does not have the answer. At least not yet. And it may never have it. But that does not stop us from contemplating the past, a very young and primordial Universe. Since the beginning of the twentieth century we know that the Universe is expanding and something that expands, although infinite in principle, necessarily increases in size. So we can say that there are different types of infinite as, even though the Universe of the distant past can also be defined as infinite, it has been increasing in size. In other words, the infinite of today is obviously greater than the infinite of the past.

The Universe of the distant past was smaller than it is today yet already contained everything that exists, has existed and will exist. Its energy density was much higher than it is today. Everything that exists now existed before but was more concentrated, tighter, occupied a smaller volume.

In this context of a very young Universe things that seem strange to us and that can normally no longer happen in the present time could occur: the transformation of matter into energy, and vice versa, was one of them. Today matter only becomes energy under very special conditions: inside stars or in nuclear bombs (to name a few better-known situations). However previously matter and energy were interchangeable, namely, when we are talking about the distant past it does not make sense to talk about one or the other of them seperately.

Matter and energy are like two sides of the same coin. This also applies to the present day, but in the present all, (or almost all), of the "coins" have only one of their sides exposed, revealing only heads or only tails. In the past, it was as if all of them (or almost all) were in the air, heads or tails, undefined. This is how the very young Universe was.

But we could also speak of an earlier period of which we know very little. It is possible that our Universe has always existed and that the expansion discovered in the twentieth century only represents the current dynamic phase of the Cosmos, in which the Universe expands so that one day it will contract. It is a cyclical movement: when it is very small it will expand again, with the cycle continuing successively and eternally. In this case humanity would only witness one moment of expansion, one which will be repeated numerous times. The other hypothesis to be considered is one in which the Universe is not eternal but had a well-defined beginning. According to this view, in which everything that is born must die, the Universe would also have a known or unknown "shelf life". However, the laws of physics are not prepared to deal with their own emergence and these unknowns about the origin of the Universe are waiting for an answer that we might never reach.

What we can confirm today as true is that in a certain moment - around 14 billion years ago - the Universe started to expand. And we call this moment the Big Bang. In its original formulation the expression Big Bang represented the instant that the Universe was born, a hypothesis conceived by George Gamow and his collaborators in the early 1940s, and it explained the current Universe very well. However, it established cosmology as a powerful parallel with the myths of theological creation (the most common in our culture is Genesis in the Bible, "Let there be Light!").

Thus, although some scientists rejected this theory - and it is important to note that in a literal sense the name Big Bang is an obviously undignified name for a hypothesis about the Universe - the alternatives proposed also did not have complete solutions. Two things survive from this divergence: the term Big Bang, created by detractors to make light of Gamow's idea; and the dichotomy that haunts us to this day, that of the infinite and the finite.

Matter and energy, which we know well, which only fifty years ago we thought was everything that existed in the Universe, makes up only 4% of everything that exists. In rounded and not very accurate numbers, the mysterious "dark matter" makes up 27% of the Universe and the remaining 69% (ie most of the Universe) is made up of the even more mysterious "dark energy".

In any case, it was at the beginning of the expansion where the "Higgs field", conceived in 1960 by Peter Higgs, stood out.[5] This field of information, later addressed in the scope of quantum mechanics (which gave birth to the famous Higgs boson, the particle that represents this field of study), permeated the early Universe and provided valuable information: some "coins that were in the air" were heads (matter), others tails (energy). And still within this analogy, the Higgs field designated values for each coin: Is it matter? What kind of matter? A Quark? An Electron? A Neutrino? Or is it energy? A Photon? A Gluon? This is how the Universe started, or at least this current phase of the Universe, referred to in the original question "Where have we come from?".

To address the next question, "Who are we?" Or "How is the Universe today?", We can divide the Universe into three major "conceptual blocks". Matter and energy, which we know well, would be block 1; the "dark matter", block 2; and "dark energy", block 3. Incredibly, block 1, which only fifty years ago we thought was everything that existed in the Universe, makes up only 4% of everything that exists.

In rounded and not very accurate numbers, the mysterious "dark matter" makes up 27% of the Universe and the remaining 69% (ie most of the Universe) is made up of the even more mysterious "dark energy". One of the central questions of cosmology with regard to this debate is the possibility that the Universe will expand forever: we know that the force of gravity has a generalized action over distance, and as weak as it may be in comparison to other forces of the Universe, it is the only one with a cumulative nature. From this it follows that if there is enough time two bodies (despite the total mass and the distance that separates them) will always end up connecting gravitationally.

[5] Peter W. Higgs, "Broken Symmetries and the Masses of Gauge Bosons", *Physical Review Letters*, vol. 13, nº 16, out 1964, p. 508-509.

Instead of studying the things in the Universe today to understand what would happen to it in the future we should see how it evolves over time and then find out what is in it today. Studies which measured the variation of the Universe's expansion rate arose from this thinking.

This conclusion is powerful and begs the question: will the bodies throughout the Universe be able to attract each other gravitationally? Or: will they be able to stop the expansion? Is there enough gravity in the Universe that one day it will stop expanding?

Despite the focus on the future the answer to the last question clearly lies in the present and to answer it we must ask ourselves what there is in the Universe today.

In the twentieth century the question was whether there was enough matter in the Universe to stop its expansion. Here we can note a fundamental distinction: the question refers to whether expansion can be stopped, not slowed. The subtle difference is in the fact that the slowing, or "braking", can be so weak that the expansion never stops, but expands at an ever slower rate. According to the twentieth century view there was no doubt about the existence of a gravitational brake on the expansion of the Universe and what we needed to know was simply whether this braking was strong or weak. In the absence of a conclusive answer both scenarios were contemplated. The original expansion, which began with the Big Bang, would become ever slower until at last it would stop and reverse. The Universe would become smaller with time until sometime in the distant future everything would shrink to a minimal volume, similar to the situation of the Big Bang.

What would happen after that? A new phase of expansion, in a model with an eternal Universe, or the end of all things? This scenario in which a densely populated Universe would possess a strong brake, is known as the Big Crunch, and enchanted cosmologists for a long time. In this theory the Universe does different things in different moments of its life, showing itself as interesting and challenging. The "death" of the Universe would be hot and convoluted.

The weak gravitational brake hypothesis conceives that the Universe is not dense in which case, in a Universe with little matter and energy, the expansion increasingly slows but never stops and continues forever. This scenario is known as the Big Chill and especially enchanted astrophysicists. A Universe that grows forever, that never collapses, would allow all of its constituents to completely live through their evolutionary cycles. In this case even if the Universe could be considered boring, as it would continue repeating itself, the same thing can't be said for what would happen inside it.

So we can think that nebulae give rise to stars and planets; that stars have time to live their life completely, dying as white dwarves or supernovas, creating planetary nebulae, pulsars or black holes, contaminating new gas clouds cyclically until there is no more primordial hydrogen and nothing more can be created. In this silent and lonely future the "death" of the Universe would be cold and slow.

Given these assumptions scientific research recognized the great need to estimate how much matter (and energy) exists in the Universe. The question would no longer be simple after the discovery of dark matter, a concept that emerged in the 1930s with the Swiss astronomer Fritz Zwicky and his studies of the dynamics of the Coma cluster of galaxies.[6] Impressed by the difference between predicted and observed movements Zwicky suggested the existence of a matter that could not be detected but nevertheless exerted gravitational force. He named it "dark matter".

This idea resurfaced with force in the late 1970s with the work of American astronomer Vera Rubin on the rotation of galaxies, in particular our own, bringing the problem to a dimension that was closer to us.[7] The existence of a type of matter that we could not detect seemed like a good solution to explain the unusual dynamics found in the observations.

So the initial question about the components of the Universe (the one that would also give us the answer about its future) is complicated. Suddenly peering into deep space and surveying what was out there was not enough. By definition there was something that would not be observed there. And that unobservable thing, the dark matter, would have a strong effect on the results sought.

Faced with this evidence the safest method appeared to be the direct study of the rate of expansion of the Universe. That is, understanding how the expansion of the Universe changes over time has become crucial not only to understand tomorrow but also today. So, instead of studying the things in the Universe today to understand what would happen to it in the future we should see how it evolves over time and then find out what is in it today. Studies which measured the variation of the Universe's expansion rate arose from this thinking. They were created for a single purpose: to find out if the brake was strong (if there was a lot of matter, including dark matter) or if it was weak.

To everyone's surprise, especially for the teams of scientists involved in the discovery, observations showed something unthinkable: the expansion of the Universe was accelerating! Not only was the brake weak but there was an accelerator, something that contradicted all existing models.

The discovery, made in the late twentieth century, revolucionized cosmology and introduced a new component into our model of the Universe: "dark energy". Unlike dark matter which carries this adjective because it cannot be seen, dark energy was so named because it is "strange, mysterious, unexpected." Its original nickname was "funny energy", or "strange energy".[8]

Today, nearly two decades after the original discovery, we have managed to divide the Universe into three well defined blocks and we know that the largest of them is dark energy, followed by dark matter and, in a distant third, everything that we are made of (ordinary matter and energy). With this discovery we can know what will happen to the Universe in the future: an accelerated expansion that will ultimately cause the fraying of space-time itself - a scenario known as the Big Rip.

The Universe does unusual and interesting things. And as we stated when talking about the definition of the Cosmos the future of cosmological research is brilliant, mysterious and full of promise. ●

6 Fritz Zwicky, "Die Rotverschiebung von extragalaktischen Nebeln", *Helvetica Physica Acta*, vol. 6, 1933, p. 110-127. 7 Vera Rubin et al., "Rotational Properties of 21 Sc Galaxies with a Large Range of Luminosities and Radii from NGC 4605 (R = 4kpc) to UGC 2885 (R = 122kpc)", *The Astrophysical Journal*, 1980, p. 238-471. 8 According to the physicist Michael Turner, author of the term "dark energy".

YESTERDAY

Earth

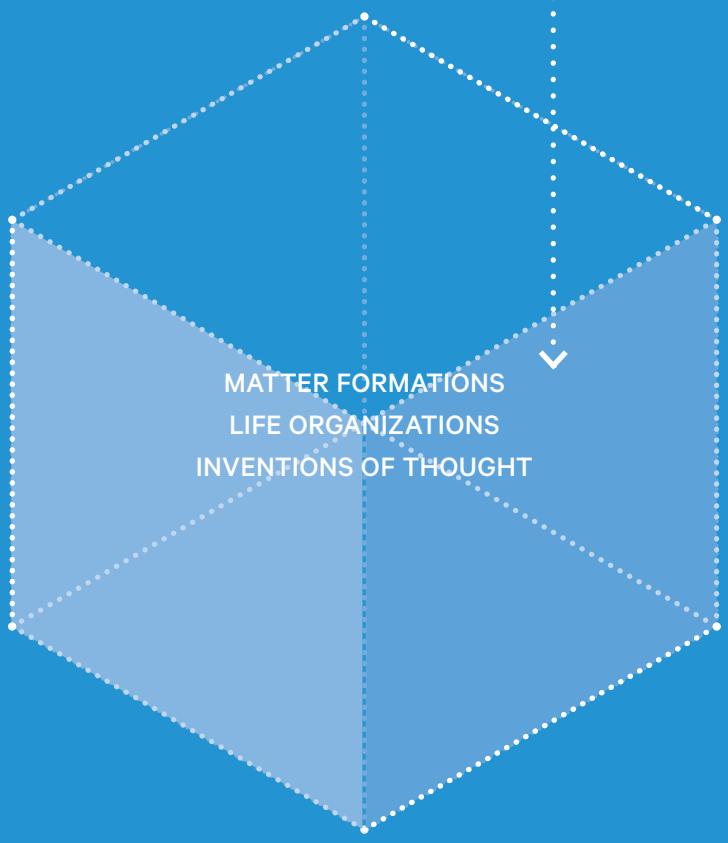
WHO ARE WE?

EARTH IS BLUE
MATTER IS FLOW

CULTURES
THOUGHT
AND DIVERSITY

4 OCEANS
MATTER IS RHYTHM

- LITHOSPHERE
- HYDROSPHERE
- ATMOSPHERE
- PHOTOSPHERE



BRAIN
THINKING IS
A NETWORK

- HOW IT WORKS
- CONSTRUCTION OF REALITY AND ILLUSION
- EXCESS BRAIN: LANGUAGE AND TECHNIQUE

DNA
LIFE IS A CODE

- THE ALPHABET OF LIFE
- ORIGIN OF BIODIVERSITY
- HOW IT WORKS
- GENETIC MATTER AND PHYSICAL CHARACTERISTICS

ECOSYSTEMS
LIFE IS A SYSTEM

EXTERNAL | INTERNAL

Made up of Matter, Life and Thought – the dimensions of our existence as earthlings – we are part of the dynamic system that is the whole Earth. To understand this system, we need to approach it from two different but complementary points of view: Unity and Multiplicity. Decades after Gagarin's pioneering flight, this now involves seeing the planet from the outside, as a single star, and understanding that the continuously combined movements of its components, whether the seas or continents, the air or light, give way to the basic rhythm of the climate, the succession of the seasons. We have analyzed and identified the basic building blocks of the genetic code that, inside all organisms, drives the development and characteristics of each species, and we are amazed by the extraordinary complexity of the associative ecosystem networks composed of countless species – both external, in which flora and fauna interact, and internal, having discovered that our body's health depends on hosting trillions of other non-human organisms. We have identified 3,000 chemical substances that comprise our nervous system and we appreciate the similar structure that makes our brain almost indistinguishable from others. We realize that, based on this basic identity, we invent all kinds of ways of living, talking, creating and feeling. We are a link in a very extensive chain, and our future depends on the maintenance of the vast, complex and dynamic network of equilibriums in the environment in which we live. We therefore understand that we are part of a whole that is much greater than the mere sum of its parts.

CLIMATE CHANGE: **THE COMPLEX GEARS** THAT CHALLENGE HUMANITY

BY GILVAN SAMPAIO DE OLIVEIRA AND CARLOS NOBRE

GILVAN SAMPAIO DE OLIVEIRA is a researcher at the Earth System Science Center (CCST) of the National Institute for Space Research (INPE). He has an undergraduate degree in Meteorology from the University of São Paulo (USP), and an MSc and PhD in Meteorology from INPE. He is the author of several books about climate change and the El Niño and La Niña phenomena, as well as many scientific papers in international and national journals.

CARLOS NOBRE is a retired INPE researcher. He is currently the president of the Brazilian Education Ministry's Graduate Education Support Agency, CAPES, and the scientific director of the National Institute of Science and Technology for Climate Change. He has an undergraduate degree in Electronic Engineering from Brazil's Aeronautics Institute of Technology and a PhD in Meteorology from the Massachusetts Institute of Technology. He has been a member of the Intergovernmental Panel on Climate Change (IPCC) for several of its assessment reports, including IPCC's Fourth Assessment Report, which won the Nobel Peace Prize in 2007, together with Al Gore. He is a member of the Brazilian Academy of Sciences and the Academy of Sciences for the Developing Nations (TWAS), and a foreign member of the National Academy of Sciences of the United States of America.

The planet is a complex system (which we term the Earth system), in which many variables – external and internal, including human actions with global effects – combine to produce the climatic conditions we have observed. The components of the Earth system constantly interact like cogs in a watch's gears, and it is hard to isolate the influence of each one. Obviously, these interactions are far more complex than simple gears.

When solar radiation reaches the Earth, it is received by the atmosphere and surface, and then converted into heat and other forms of energy, producing the circulation of winds and ocean currents, for example. At the same time, the different types of surface – vegetation, desert, water, snow or ice – have a fundamental effect on the quantity of solar radiation that will be absorbed or reflected.

Once each region's climatic patterns have been established, especially those related to temperature, precipitation and moisture, they dictate the types of living organisms that will proliferate in the planet's different areas. In a reciprocal manner, living beings – especially plants – will also decisively affect the climate as they receive and emit greenhouse gases, among other influences they have on the environment. Through agriculture and industry, humans appear in this complex system, putting pressure on the environment. All of these factors, operating concurrently, have an influence on Earth's climatic configurations.

To understand how this complex planetary system functions, scientists have created the field of study called "Earth system science,[1]" in which natural, social and other sciences interact in a single context. The goal is to understand the dynamics of complex interaction between natural and social systems, with bio-geophysics, biogeochemistry and biodiversity on the one hand, and human systems such as politics, culture, economics and demographics on the other hand. To better observe the physical elements that make up this science's object of study, specialists tend to classify the different parts of the Earth system in the following spheres, which overlap and interact with each other: the photosphere, atmosphere, hydrosphere, biosphere, cryosphere and lithosphere.

The hydrosphere is composed of water, the most abundant substance on the planet, covering around 77% of the surface. It is mainly formed by sea water, where the dynamics of ocean currents distributes heat across the globe and helps to make many regions inhabitable. The oceans are also largely responsible for providing the atmosphere with water vapor. The atmosphere then transports it to the continents, where it turns into clouds and rain, feeding rivers and lakes, besides contributing decisively to life throughout the planet.

All the frozen water existing on Earth makes up the so-called cryosphere (part of the hydrosphere), which has a major influence on climate. Because it is a light color (white), ice is an excellent reflector of solar rays. However when ice floating on the sea surface melts (due to a rise in Earth's sea surface temperature, for example), the solar rays that were previously reflected are now absorbed by a darker ocean. This absorption of solar radiation raises the local air temperature, inducing ever more melting of ice, in a cycle that accelerates the reduction of the area covered by it.

Another important sphere is the atmosphere, a layer of gases surrounding the Earth, whose composition is one of the climate's key elements. Its most commonly found substances are nitrogen (which makes up around 78% of the total volume of gases) and oxygen (approximately 21%). Other substances, such as water vapor, carbon dioxide, methane and ozone, despite appearing in small concentrations, play a central role on climate, as they induce the natural warming of the surface of the planet and troposphere (the lowest and densest layer of the atmosphere) through the atmospheric greenhouse effect: the higher the concentration of these gases, the greater the warming is.

1 This idea gained momentum in the 1980s in the United States, where this term arose, leading to the establishment of several research centers, which started to work from the perspective of integration. In Brazil, this research field only gained prominence in the past decade.

Through the dynamics of air masses, the atmosphere is largely responsible for the distribution of heat and rain, as the movement of gases does not respect frontiers and influences the whole planet. A classic example of this subject is the El Niño phenomenon (the warming of Pacific Ocean waters near the Equator), which has effects on the entire planet's climate, including in Brazil. Just as we may find ashes from Amazon forest fires in the middle of Antarctica, we are sure that, if we alter the conditions of a given region (by felling and burning forests, for example), we will be inducing the occurrence of alterations in other parts of the globe. The planet is completely interlinked through the atmosphere and oceans.

Alongside the hydrosphere and atmosphere, the third primordial component of the Earth system is the biosphere, which includes life in its different forms: plants, animals, marine and land organisms, both macroscopic and microscopic. Large forests such as the Amazon play a fundamental role in the process of absorbing water in the soil and evaporation to the atmosphere, contributing to the formation of clouds and rain. The biosphere also has a notable influence with regard to concentrations of carbon dioxide – which plants absorb from the air and return oxygen through photosynthesis.

Finally, there is the lithosphere, the outermost solid layer of the planet, which also plays an important role, especially due to its release of enormous quantities of energy, gases and aerosols through phenomena such as volcanic eruptions. In addition, the movement of the tectonic plates that form Earth's crust is responsible for shaping the continents, over hundreds of millions of years, thereby affecting the ocean currents, global climatic patterns, the environment, and the composition and distribution of species.

Also considering human beings' effects on nature, the global scientific community is faced with the enormous challenge of answering the following questions: What is happening to the climate? How may these changes affect our lives, our diet, our health and the environment around us? Is there something we can do to minimize the negative impacts of these changes?

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A little over 20 years ago, the majority of countries signed up for the United Nations Framework Convention on Climate Change, an international treaty[2] to reduce global warming risks and deal with the inevitable impacts of temperature increases. In 1997, dozens of nations approved an addition to this treaty, the Kyoto Protocol, which recognized the responsibility of developed countries regarding the high levels of greenhouse gas emissions arising from their industrial and agricultural activities and established concrete objectives to reduce these emissions between 2008 and 2012 – later extended to 2020.

These political measures are a response to different climate studies carried out throughout the world and pressure from the global scientific community concerning the importance of minimizing the consequences of human effects on climate change. Among laymen, the best-known international initiative in the area is probably the UN Intergovernmental Panel on Climate Change (IPCC), a group of specialists who are dedicated to compiling scientific data and summarizing the progress of knowledge about climate change to guide decision-making in the field. The IPCC's work has been reported prominently in the media, underpinning global discussions about climate change, its impacts and steps we can take to deal with climate issues.

In Brazil, interest in the subject of global changes was initially and mainly motivated by the Amazon forest's importance for the planet's climate, as it was necessary to understand the consequences of these changes for the forest and the climate. Starting in the 1980s, part of the international scientific community turned its attention to the region. Until the mid-1990s, the majority of research projects carried out there were led by foreign groups, but this work helped to empower Brazilian researchers to do their own work, conducting successful projects about the issue.

Some studies indicate that by the mid-21st century, part of the Amazon may experience a process through which tropical forest is replaced by savannah or semi-deciduous forest, which could mean impoverishment from a biological point of view.

The international scientific community's efforts to study the Amazon have not been made by chance, of course. The region gives rise to major concerns when we project the potential global impacts of the gradual disappearance of this forest. The Amazon region is home to the largest remaining area of tropical forest in the world, performing a fundamental role in hydrological and climatic regulation for a vast area of South America, besides possessing a large stock of carbon and exceptional biodiversity.[3] Despite this, it is known that more than 18% of the native forest has already been destroyed. Some studies indicate that by the mid-21st century, part of the Amazon may experience a process through which tropical forest is replaced by savannah or semi-deciduous forest, which could mean impoverishment from a biological point of view. Nevertheless, there are still few analyses of the effects of climate change on biodiversity. We know that large deforested areas may induce modifications in the hydrological cycle, which would make the regional climate hotter and drier. This would also favor the occurrence of fires, with serious consequences for nature and local communities.

In addition to the degradation of the Amazon forest, another key issue in climate studies is the behavior of oceans. Even if a change in ocean dynamics is seemingly small, it may produce large climate variations in many areas of the planet.

2 To access the 1994 United Nations Climate Change Conference report, see http://unfccc.int/essential_back-ground/conventionitems/2627.php. Consulted on August 16, 2015.. 3 Philip M. Fearnside, "Biodiversity as an Environmental Service in Brazil's Amazonian Forests: Risks, Value and Conservation", Environmental Conservation, vol. 26, no. 4, 1999, p. 305-321.

One of the biggest concerns is about the expansion of waters as they heat up. The waters of the ocean's surface layers have already risen in temperature by around 0.6°C over the last 50 years, and the warming is slowly penetrating the deeper water layers. This warming causes a thermal expansion of water and, added to the volumes arising from glaciers melting and flowing into the oceans, this is resulting in an alarming rise in the mean sea level of around 2 to 3 millimeters per year. This amount may seem insignificant to some people, but scientifically speaking it will represent a very considerable increase after a few decades. The consequences include not only the loss of ecosystems, but also more frequent flooding of coastal cities and increased vulnerability to severe storms.

The oceans are also responsible for absorbing around one-third of all carbon emissions produced by human action, reducing Earth's amount of atmospheric carbon dioxide, which is associated with the planet's warming. However, studies show that climate change is negatively affecting the absorption of carbon by the oceans,[4] as hotter water is not capable of maintaining as much carbon dioxide as colder water, and ocean warming may possibly lead to an increase in concentrations of the gas in the atmosphere. In other words, we do not yet know for how long the oceans will continue to sequester anthropogenic carbon at present levels. Even more worrying is the fact that the absorption of carbon dioxide by the oceans makes waters more acidic. Ocean acidification could pose serious risks to marine life.

Given the evidence of how the world's climate is changing, it is up to us to evaluate now the extent to which it is possible to contain this process – or at least the bulk of it occurring as a result of human action – and on the other hand, the extent to which we should organize ourselves to tackle the consequences of global warming. We should consider how countries or cities may experience more frequent natural disasters, including severe storms, floods and prolonged droughts; how to deal with diseases brought about by new climate configurations; and how to adapt agriculture to the new conditions.

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4 Galen A. McKinley et al., "Convergence of Atmospheric and North Atlantic Carbon Dioxide Trends on Multidecadal Timescales", Nature Geoscience, vol. 4, 2011, p. 606-610.

In this context, an important concept is vulnerability to climate effects – "the capacity of a social group or individual to deal with, anticipate and recover from the impacts of disasters."[5] Research projects in this area consider that different populations have higher or lower levels of vulnerability, depending on factors such as income, culture, education and political power.

In Brazil, a mapping of the vulnerability of different regions to the impacts of climate change[6] has showed, for example, that the Northeast is among the regions that will suffer the most, not only from environmental consequences, but also epidemiological and socioeconomic ones. It is forecast that there will be a worsening of problems such as endemic infectious diseases (malaria, leishmaniosis, leptospirosis and dengue fever), accidents involving natural disasters and extreme weather events (landslides, storms and floods), reductions in agricultural yields and malnutrition in areas already affected by food insecurity.

From the Brazilian economy's perspective, preliminary results suggest that climate change will have negative effects on the country's growth and human wellbeing, although some sectors and regions may be positively affected. In addition, one issue to be seriously considered is that climate change may help to reinforce regional economic inequalities in Brazil.

Studies suggest that climate change ought to be analyzed in conjunction with globalization (increase in connections between people in trade and information), environmental changes (degradation of ecosystems, reduced biodiversity and accumulation of toxic substances in the environment) and the weakening of governance systems (via lower health investments, higher dependence on markets, and growing social inequalities), given that all these factors strongly interact in a complex manner.

Preparing for and adapting to global climate change and its impacts, and mitigating its effects, are not only tasks for government leaders. Scientists believe that to reduce the impacts of climate change, greenhouse gas emissions will need to be cut in half by 2050, and eliminated by the end of the century – a bold target, but something that the population may contribute to. Some important initiatives include the following: reduce energy consumption and improve energy efficiency by introducing more renewable clean energy sources such as solar and wind, and by using public transport or bicycles; capture carbon under the ground through sustainable agriculture; and preserve forests, which absorb carbon in the soil and trees. It is estimated that emissions may be reduced by one-third by 2030 if such practices are adopted.

Other steps that are within everybody's reach are as follows: avoid burning organic compounds or garbage in general; plant more trees and cultivate green areas; reduce and recycle waste; make frequent inspections of vehicles; save water; choose biodegradable products; consume less meat; use less packaging; avoid disposable products; seek to consume organic food... The list is long, and conscientious citizens will certainly find ways to play their part. ●

5 Piers Macleod Blaikie et al., At Risk: Natural Hazards, People's Vulnerability and Disasters, London: Routledge, 1994. 6 Ulisses Eugenio Cavalcanti Confalonieri, "Mudança climática global e saúde", Com Ciência, vol. 85, 2007, p. 5.

THE LABYRINTHS OF **DNA**

BY MAYANA ZATZ AND ELIANA DESSEN

Would you like to know everything that is written in your DNA? Test which genetic diseases may affect your health and perhaps, in future, determine your lifespan? And choose which genes you would prefer to pass on to your children and which ones to cross off the map? **What would** you do if you could decipher the information contained in your genome?

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Every day, geneticists have a fine balance to achieve: if they are not sufficiently bold, they will not access new fields of science uncovered by DNA sequencing; but if they are too bold, they will go beyond ethical boundaries.

Unlike results found in clinical tests, such as those that measure cholesterol or blood glucose, the alterations found in a DNA test do not change. They remain the same throughout our lives. Thus, the results of a genetic test can have a major impact on our life, affecting family relationships and decisions about having children. Therefore, before revealing a diagnosis or predicting a genetic condition, it is fundamental to discuss the implications of this knowledge, why we want to know it, and what will be done with the obtained information.

To this end, it is first necessary to consider which of our characteristics depend on our genes and which on the environment. In some cases, genes are determinant, meaning they are not influenced by the environment (our blood group, for example). In other cases, the environment is determinant (regarding whether we learn to read and write, for example). For the majority of characteristics, however, there is an interaction between our genes and the environment, activating or silencing genes. Understanding each factor's role is crucial in order to interpret a genetic test, manipulate the environment (such as through the diet of people with a tendency to suffer from diabetes) and, in future, manipulate genes, so as to achieve desired goals.

According to American biologist Edward O. Wilson, who coined the term "biodiversity", biology is a three-dimensional rather than a linear science.[1] And the code of life, DNA, should also be read in three dimensions. In Wilson's view, "the first dimension is the study of each species at all levels of biological organization: from the cell to organisms, populations and the ecosystem. The second dimension is the diversity of all species in the biosphere. Finally, the third dimension is the history of each species, encompassing both its genetic evolution and also environmental changes that orchestrated its evolution."

A large part of the future of biology depends on adopting an interdisciplinary approach to permit a tour of these three dimensions. The starting point is not simple, not even when we examine a cell. Unlike a "bag of molecules", a cell consists of a functioning biological system, it has basic components – such as DNA, RNA and proteins – with interactions between these components and with the environment. The property that emerges from this biological system – defined as follows – is life.

This awareness of a whole that is greater than the sum of its parts marks 21st-century biology. Unlike the reductionist theories of the past, a biology of systems is now emerging, whose objective is to explain how complex behaviors arise from collections of simpler components. In turn, this knowledge enables synthetic biology, whose goal is to recreate an unnatural chemical system with the properties of living systems, including genetic inheritance and evolution.

All biological systems are complex. They are like living labyrinths; pyramids full of corridors, halls and secrets to be deciphered. Systems are not linear, and when their individual components interact, they create so-called "emerging" properties and functions. These properties can only manifest themselves if the organism is seen as a whole; otherwise it is like getting lost in a three-dimensional labyrinth, without noticing the pyramid.

Even the simplest life forms have unpredictable emerging properties, presenting enigmas for traditional engineering. Understanding the behavior of biological systems, at their various levels of organization, depends on studying the complex, dynamic interactions between their components. This calls for detailed mathematical models of the biochemical and biophysical structure of systems, to experience simulations and, perhaps, arrive at the desired forecasts.

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In 2001, the first draft of the human genome was published. In 2003, two years ahead of schedule, Francis Collins and Craig Venter announced the completion of the sequencing of the human genome, although new genes were still being discovered. However, to understand how genes function, how they interact among themselves and with the environment, will require another 100 years of research.

Determining genes that start to function or are silenced, for example, depends on several "epigenetic" factors, which are still the subject of much research. They may vary in line with the type of cell or age. Genes that express themselves during embryonic life or during growth, for example, may be silenced in the adult phase. A same genetic mutation may determine a genetic disease in one individual, while in another individual the conditions to activate this gene may never occur. Understanding what protects some people from the harmful effects of a mutation is of great interest as it may result in new treatments.

1 Edward O. Wilson, "Systematics and the Future of Biology", Proceedings of the National Academy of Sciences, vol. 102, sup. 1, 2005, p. 6520-6521. (This work was an outcome of the National Academy of Sciences' Arthur M. Sackler Colloquia, "Systematics and the Origin of Species: On Ernst Mayr's 100th Anniversary", which took place from December 16 to 18, 2004, at the Arnold and Mabel Beckman Center of the National Academies of Science and Engineering in Irvine, California.

People with the same mutation responsible for a genetic disease may present completely different clinical conditions, just as, on another timescale, in the spiral of evolution, common ancestors gave rise to very different species. The primary source that originates diversity is mutation, meaning DNA sequence alterations, which may be caused by events occurring during the duplication of DNA or mutagens such as radioactivity, ultraviolet rays or carcinogenic drugs.

Natural selection operates on new sequences generated through mutation: the diversity of life forms on Earth arose from mutations selected in line with the highest reproductive capacity over time. From the very first cell's DNA, through mutation and recombination mechanisms, there arose an infinity of life forms on Earth.

The time dimension – evolutionary history – shows us how all living beings are to a greater or lesser extent related to each other. Some percentages of shared sequences between the human genome and those of other species are astonishing: we have 95% in common with chimpanzees, 89% with mice, 45% with fruit flies, and even 9% with *E. coli*, a bacterium found in people's intestines.[2] This similarity is an indication of the common origin of all living beings and enables the analysis of divergences from one species to another.

Genome sequencing is a way of "reading" the order in which the bases ("letters") are arranged in a molecule. Once the sequence of bases – the message contained in the molecule – is known, there begins a long and complex study to analyze and understand its meaning. Computers and special programs are used by bioinformatics specialists to predict the location of genes, in other words the segments of the sequence corresponding to protein synthesis information.

The next step is to predict the genes' function, which is done by comparing the new sequence obtained with well-studied model organisms. Comparison of the genes of different species also makes it possible to infer kinship between these species, establish evolutionary relationships between them and determine the importance of essential genes, conserved through evolution. This comparison may also be made between individuals of the same species, but with different functions, such as social insects organized into castes – ants and bees, for example.

Some species even constitute a super-organism formed of interdependent organisms, which come together to cooperate to solve survival problems. The individual intelligence of army ants is minimal, but together they make up one such super-organism. Using their collective intelligence, they march through the forest, creating their own paths, killing and devouring everything in their way. In the early evening, they pile up so as to form a protective shield with the worker ants on the outside and the young larvae and queen at the center. At dawn, the living ball disassembles itself and the cycle restarts. There is no central controller: collective intelligence creates patterns, uses information and evolves. In this case, the DNA sequence of each ant is the same, but the individuals in each caste take on distinct characteristics, based on epigenetic alterations. In other words, their DNA acquires "marks" and some genes may be silenced or activated.

Human beings also coexist with a huge population of microorganisms (bacteria, fungi and viruses), called microbiota. We have 10 times more microbes than cells, which are born with us and accompany us throughout our life, and which also form a "super-organism" with us. The role of the microbiome, which greatly influences our health, has been the subject of numerous studies. Understanding the relationships between the information contained in DNA (genotype) and phenotype (characteristics) is a central goal in genetics. The biggest challenge lies in our capacity to manipulate, interpret and translate, through predictive models, the enormous quantity of data generated by new molecular analysis technologies (next generation sequencing). This requires the development of bioinformatics and the creation of massive databases.

2 The percentages presented in this text were taken from the Genomic Revolution scientific exhibition, created by the American Museum of Natural History in New York and adapted by the Sangari Institute for its Brazilian edition (called "Revolução Genômica"). However, most of the time the percentages obtained by comparing genomes cannot in turn be directly compared. This is because comparisons of the genomes of different organisms (compared genomics) are made at different levels, generally depending on the time when the two compared organisms diverged from their common ancestor. Consequently, these comparisons are not equivalent. Inferences are often drawn about the raw sequence results to make more equivalent comparisons. Nevertheless, for the purpose of informing the general public, the details about how these comparisons are made tend to be left out. A detailed explanation of the types of comparisons made can be found in Ross C. Hardison, "Comparative Genomics", Plos Biology, vol. 1, no. 2, 2003, p. 156. For complementary comparison sources, see M.D. Adams, "The Genome Sequence of Drosophila melanogaster", Science, vol. 287, 2000, p. 2185; Frederick R. Blattner et al., "The Complete Genome Sequence of Escherichia coli K-12", Science, vol. 277, 1977, p. 1453; Eric S. Lander et al., "Initial Sequencing and Analysis of the Human Genome", Nature, vol. 409, 2001, p. 860; Laurie J. Mullins, "Insights from the Rat Genome Sequence", Genome Biology, vol. 5, 2004, p. 221; Gerald M. Rubin et al., "Comparative Genomics of the Eukaryotes", Science, vol. 287, 2000, p. 2204; "The Chimpanzee Sequencing and Analysis Consortium: Initial Sequence of the Chimpanzee Genome and Comparison with the Human Genome", Nature, vol. 437, 2005, p. 69-87; Ajit Varki and Tasha K. Altheide, "Comparing the Human and Chimpanzee Genomes: Searching for Needles in a Haystack", Genome Research, vol. 5, 2005, p. 1746-1758; and John Craig Venter et al., "The Sequence of the Human Genome", Science, vol. 291, 2001, p. 1304.

In the near future, bioengineering will make it possible to fabricate or "repair" organs in laboratories. [...] We will have organ repair "workshops."

Through the development of knowledge and the capacity for analysis, science can go far beyond diagnosis. The cloning of Dolly the sheep in 1996 by Scottish researchers demonstrated for the first time that an adult mammal cell could be reprogrammed, return to the embryonic stage and give rise to a copy – a clone – of that animal. The great post-Dolly revolution paved the way for research into stem cells, the future of regenerative medicine.

Adult stem cells, found in adipose tissue, the umbilical cord, dental pulp and bone marrow, among other tissues, have the potential to form fat, cartilage and bone. When injected into model animals, they have been shown to be clinically beneficial for their immunomodulatory role, reducing inflammation, enhancing blood circulation and improving the tissue environment of the recipient organism.

Moreover, mature adult cells, removed from humans or other animals, can be reprogrammed to turn into induced pluripotent stem cells, which have the capacity to generate all types of tissues. They are very similar to embryonic stem cells, but they are not identical, as they retain the "memory" of where they were removed from.

In the near future, bioengineering will make it possible to fabricate or "repair" organs in laboratories. People with heart problems, for example, will be able to have their heart removed, "replaced " with tissues and/or valves regenerated from stem cells, and then put back in place. We will have organ repair "workshops."

In agriculture, the genetic improvement of crops is already making an enormous contribution to food production and the reinforcement of resistance against adverse weather, salinity, pests or diseases. Geneticists are now working to accelerate these processes, through molecular markers, genetically modified food, cloning and even synthetic genomes.

By manipulating genomes at this level, bioengineers deal with tens of thousands of genes that make up the DNA of each being. In our organism, around 20,000 genes permit the manufacture of all proteins. Together, however, they only occupy 2% of human DNA molecules. Until very recently, the remaining genes were treated as "junk DNA": "useless" genetic sequences whose function was unknown.

Nevertheless, these genes are certainly not junk. Quite the opposite. More than 30 papers have been published by the Encyclopedia of DNA Elements (ENCODE) international research consortium, demonstrating the existence of millions of "switches" in this 98% of the human genome. These genes do not encode proteins, but they serve to turn genes on and off in line with the type of cell and the development phase of the organs and tissues in which they are found. They make up a mega control panel, dictating when, where and in what quantities genes will make proteins. Without these regulatory elements for genetic activity, our 20,000 genes would be only inert fragments.

As we have seen, knowledge can make leaps and present us with unexpected keys to decipher the secrets of biological functions. This fact ought to make us more humble: despite knowing a lot about the code of life, this only gives us a faint idea of the infinite possibilities of dealing with the labyrinths of DNA. ●

HUMANITY AND BIODIVERSITY: **THE RISK OF EXTINCTION** OF SPECIES IN TERRESTRIAL ECOSYSTEMS

BY MARIA ALICE DOS SANTOS ALVES

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Our planet, Earth, the only one in this immense Universe known to harbor life, contains an enormous variety of living beings, which we call biological diversity, or biodiversity. It is estimated that there are around 10 million species currently living on Earth, not including microbes and underestimating small species, such as those that live in places that people find hard to reach, like the oceans. The total number of identified species, with scientific names, is roughly 1.5 million, although some recent estimates put this figure at 1.75 million (including around 100,000 terrestrial vertebrates, flowering plants and invertebrates with wings or shells). Of this total, birds and mammals are relatively well known, amounting to around 10,000 and 4,300 species, respectively, although new species continue to be discovered. Regarding marine species, just 250,000 to 300,000 have been described, and there are still many to discover.[1]

When it comes to us, human beings, although we appeared recently on this planet's evolutionary timescale, we have occupied virtually all the land environments. The Industrial Revolution's process of economic and social change (in the 18th and 19th centuries), which led to an increase in food production and life expectancy, also triggered rapid population growth. In recent decades, this greater presence of people on Earth has caused an intensification of human action on nature, resulting in accelerated environmental destruction and degradation, and consequent strong pressure for loss of biodiversity.

If we consider the last 500 years, 844 species have gone extinct, according to the International Union for Conservation of Nature (IUCN). Of this total, although extinctions have also often occurred on continents in the last two decades, the majority of them have taken place on oceanic islands.[2]

To find a local extinction, we do not have to go very far. One example in the state of Rio de Janeiro is the tropical mockingbird, *Mimus gilvus*, known for its song, greatly appreciated by humans. At the time Brazil was colonized, this bird was found throughout the state's coast, but the species now only has established populations in four areas of restinga (sandy coastal vegetation) in the region, where it is endangered by the loss of its habitat and illegal capture.[3]

Scientists believe the current rate of species extinction is, on average, between 100 and 1,000 times higher than pre-human levels, and it is on the way to being 10,000 higher.[4] These figures are considered to be very high and indicate that the situation in recent years is one of rapid extinction, with an accelerating trend. Given this reality, one may say that the extinction of species, despite being a naturally occurring and irreversible event, has been taking place on an unprecedented scale because of human pressure.

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1 For the mentioned estimates, see Stuart Leonard Pimm et al., "What is Biodiversity?" in Eric Chivian and Aaron Bernstein (orgs.), Sustaining Life: How Human Health Depends on Biodiversity, Oxford: Oxford University Press, 2008, p. 3-27. 2 Idem. 3 Mariana S. Zanon et al., "Missing for the Last Twenty Years: The Case of the Southernmost Populations of the Tropical Mockingbird *Mimus gilvus* (Passeriformes: Mimidae)", in Zoologia, vol. 32, 2015, p. 1-8. 4 Stuart Leonard Pimm et al., *op. cit.*

As well as already frequent tsunamis, tornados and hurricanes, we have witnessed ever more climate change resulting from environmental alterations brought about by human beings, causing disasters such as extreme flooding and droughts. In addition to loss of habitat (and its consequent fragmentation) and climate change, which are threatening many species (particularly endemic ones),[5] another aggravating factor now poses a great threat: exotic and invasive species. They may have a very negative impact for the survival of many species, especially native ones that make restricted use of habitat.

It is well known that ecosystems are critically dependent on biodiversity, meaning the species and populations that make them up, and their good functioning is vital to the maintenance of species on the planet, allowing them to provide environmental goods and services. When a species is extinguished, the same thing is likely to happen to many others, which interact in ecosystems, forming food chains, for example.

To understand what an ecosystem is, one should take into account not only the set of living beings but also the interactions they establish between themselves (such as the effects that different populations cause on one another) and with the physical environment (such as temperature, precipitation, rain and wind). In other words, ecosystems are composed of all the parts of the physical and biological world they interact with.

Among these interactions, those that take place between organisms may be considered positive or negative if they increase or decrease their population sizes, respectively. Therefore, interactions between species (such as competition, predation, parasitism, mutualism and commensalism) are multiple and permit there to be a network between them. They are shaped by evolution and take place naturally in an ecosystem.

Most of the time, positive human interventions seek to reverse or neutralize negative interventions carried out directly or indirectly by human beings themselves, such as environmental destruction and degradation, which lead species to become endangered, and therefore loss of biodiversity.

[5] Endemic species are those restricted to a certain habitat, and therefore more susceptible to extinction.

External interventions, such as those imposed by human beings, may also be positive or negative. However, the reality is that most of the time, positive human interventions seek to reverse or neutralize negative interventions carried out directly or indirectly by human beings themselves, such as environmental destruction and degradation, which lead species to become endangered, and therefore cause loss of biodiversity. An example of a positive intervention aimed at reversing a negative situation is management to increase the size of a threatened species' population, or to reduce or control an exotic or invasive species.

If we look to the future, given the threat to biodiversity now posed by human action, we can predict changes that may be gradual or sudden over the next 50 years. Changes that may occur gradually include alterations to the distribution of species due to changes in climate, such as rises in temperature. In addition, even for widely distributed species, there may be a loss of biodiversity within their distribution boundaries, through local extinction (of part of a species' populations, with a consequent loss of genetic diversity). As the majority of environmental or ecosystem services (benefits provided by nature) depend on biodiversity, the loss of local populations may lead to a reduction in these services, such as pollination and seed dispersal performed by different animal groups, like birds and mammals.

As for sudden changes, over the next five decades we may lose a large share of species that are endangered and whose distribution is heavily restricted. This may largely be caused by habitat loss, but also the introduction of exotic and invasive species (whose effects may be devastating) and climate change (increases in temperature and a consequent rise in sea level).

Although it is hard to make predictions about species extinctions because of the numerous variables involved, researchers have shown that global climate change will result in the extinction of a considerable number of species in the coming decades. For many groups of plants and animals investigated, estimates have been made that 15% to 37% of species will become extinct as a result of the direct or indirect effects (habitat alterations) of the temperature increase projected for 2050.[6] Some species of flora and fauna, particularly endemic ones that are restricted to small portions of coastal environments, for example, may became extinct in this period.

One of the questions that arises in this context is: how much longer will our species be able to live in a sustainable manner on this planet if we continue to alter nature the way we are doing now? To reverse this situation, we will need initiatives such as awareness raising in society about these threats, government programs to monitor species – especially endangered and/or endemic ones – and also activities to manage exotic and invasive species.

In response to the question "what will tomorrow be like?" we can respond that it will be the consequence of what we do today. If we reduce the current negative pressures, we may be able to avoid the most pessimistic scenarios in scientific forecasts. Attitudes such as think, plan and act locally may be reflected in global actions. Raising the awareness of human beings so they feel like just one of many other living beings is vital for us to be able to preserve the most precious resource we have on the planet, namely the biodiversity of which we are a part. ●

6 Chris D. Thomas et al., "Extinction Risk from Climate Change", Nature, vol. 427, 2004, p. 145-148.

GUANABARA BAY, A LOOK AT HISTORY

BY ELIANE CANEDO DE F. PINHEIRO

A living witness to our history, Guanabara Bay holds relics dating back thousands of years. The discovery of archeological sites near its banks indicates that these waters may have been used by prehistoric people – known as "sambaquis" ("midden") people.[1] At these sites, the fossils of small marsupial mammals, terrestrial mollusks, birds and reptiles have been identified, as well as chipped stones and ceramics, which tell us a little of this history.

Other research carried out by geographers and geologists concluded that, thousands of years ago, the sea level was around 130 meters below its current level.[2] At this time, therefore, on a large part of the currently submerged continental shelf, there used to be areas of restinga (sandy coastal vegetation), cliffs and dunes, which were home to exuberant megafauna such as mastodons, saber-toothed tigers, giant armadillos, and sloths as much as six meters long.[3] The cause of these animals' disappearance is still uncertain: there may have been a shortage of food arising from the last ice age, or they may not have survived the rising waters of the Atlantic Ocean throughout the continental shelf's coastal zone. At any rate, it is known that it was this flooding event, around 12,00 years ago, that gave rise to Guanabara Bay.[4]

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1 Alberto Ribeiro Lamego Filho, "O homem e a Guanabara", Rio de Janeiro: Biblioteca Geográfica Brasileira, IBGE, 1964. 2 Francis Ruellan, "A evolução geomorfológica da baía de Guanabara", Revista Brasileira de Geografia, year IV, no. 4, Oct-Dec 1944, in Alberto Ribeiro Lamego Filho, *op. cit.* 3 Elmo Amador, "Baía de Guanabara e ecossistemas periféricos: Homem e natureza", author's edition, 1997. 4 Colomb and Houlbert, "La geologie", in Alberto Ribeiro Lamego Filho, *op. cit.*

However, numerous changes to the bay's initial outline were successively brought about by weather and environmental events, accompanied by successive alterations in sea level, until it finally took the shape found by the first Portuguese settlers who arrived here in 1502.[5] We were already in the modern age, and the Europeans were concerned to keep records of their discoveries. Since then, it has been easier to reconstitute the bay's history. Drawings, maps, texts and paintings produced by the colonizers have facilitated the work of historians who have reconstituted its trajectory over the last five centuries, recording the transformations it has continued to go through.

The current bay is very different to that one of clear waters, shaped and adorned with little coves, beaches and mangroves, set against a backdrop of dense tropical forest: a vision of blissful paradise for the Portuguese navigators who saw it for the first time. They were travelers who, following the orders of King Manuel I, the Fortunate, had undertaken a mission to explore the Brazilian coast nearly two years after the land's discovery. When they entered the bay, flanked by splendid granite mountains, they believed they were at the mouth of a great river. As it was January 1, they named the area "Rio de Janeiro" ("River of January").

After getting over their disappointment at not having found an arm of the sea they had been looking for to reach the Pacific Ocean and from there the Orient, they soon realized they were in a very lush place, unlike anything they had seen before. From then on, travelers from across the world did not tire of celebrating the beauty of that virgin paradise of clear waters, full of fish. The open sea and bay dotted with islands and islets, beautiful beaches, and exuberant tropical flora and fauna helped to make up a landscape that to Europeans at that time was redolent of the Garden of Eden.

An imposing mountain range covered in dense tropical forest dominated the landscape, skirting the Atlantic Ocean. Between the sea and the mountains, there were small hills dotted around, surrounded by marshes, lagoons and mangroves. There were gigantic trees, orchids, huge butterflies and a lot of water: in the sea, bay, lagoons, rivers and waterfalls. Here and there, the dense green cloak of jungle seemed to want to touch the sky by means of the tops of palm trees emerging from the ocean of leaves.

The vibrant tones and intoxicating perfume of flowers and fruits lent more liveliness to the mysterious nature. The diversity of vegetation typical of regions with a hot and humid climate enchanted travelers, who were used to the difficulties of European winter and cold. People's attention was scattered by the kaleidoscopic vision of colors and shapes: water lilies that floated placidly in lagoons; pineapple, pitanga and cashew fruit trees that miraculously flourished in sandy coastal areas; leafy jabuticaba trees replete with a kind of very sweet black cherry; and even bromeliads that sprouted on "itaporapuãs", the name given by indigenous people to the large round boulders that cropped up unexpectedly in the middle of forests, waters and sands.

Parrots, toucans, herons, macaws and scarlet ibises flew in large flocks, painting the sky in countless colors. Felines and other small mammals – jaguars, collared peccaries, capybaras, pacas, tapirs, deer, monkeys and marmosets – approached calmly, without fear, to drink the clear waters that came down from the mountains, through the virgin jungle, in which acacia, jequitibá, cecropia, ipê and purple glory trees stood out due to their colors.

[5] Elmo Amador, *op. cit.*

Large shoals of sardines, corvina, common snook, mullets, horse-eye jack and other fish that lived in the bay enticed groups of dolphins into the middle of it, to the vicinity of the island of Paquetá, in search of food. In the winter months, groups of dozens of whales could be seen, gently gliding through the bay's waters, after crossing the bay entrance in search of warmer coastal waters in which to give birth. The beaches and mangroves were home to many shrimp, crabs, mussels, oysters, yellow clams, wedge shells and cockles.[6]

The first reports written by travelers who came here in the 16th century describe – in generally superlative language – the heavenly natural environment that extended throughout the Brazilian coast, where there lived, in perfect harmony with nature, an indigenous population that was very homogenous in terms of language and culture: the great Tupi-Guarani nation.

This would perhaps still be the situation today, if the Europeans had not come to Brazil and if the Tupi-Guarani people had continued to inhabit the bay's islands and shore, keeping it preserved and guaranteeing that its wild beauty remained virtually untouched. The historical process was inexorable, however. The recently discovered land was settled, in line with the standards of the time, inevitably. As in any other part of the world, it was up to colonizers to take advantage of the wealth of discovered lands.

In Brazil, as in many other colonies, extraction of natural resources was the economic model adopted in the first centuries under Portuguese rule. The extraction of brazilwood ("pau-brasil") to make dyes and whaling (all the parts of whales' bodies could be used, for many purposes, ranging from food to construction) were commonplace activities. Furthermore, the Europeans deemed it necessary to subdue the local nature, which although stunning, was extremely threatening, posing numerous dangers and discomforts: enemy Indians, fierce and poisonous animals, frightening storms, scorching heat, and annoying insects that transmitted unknown tropical diseases.

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6 Augusto Ivan de F. Pinheiro and Eliane Canedo de F. Pinheiro, "Encantos do Rio", Rio de Janeiro: Salamandra, 1997.

A little more than five centuries later, the schools of whales and dolphins that used to gently glide through the bay have vanished. Of the indigenous tribes that lived along its banks, there are now only reports, a few middens and the original Tupi-Guarani names that continue to identify the geographical features and places along its shores, starting with its own name, Guanabara, or "bosom of the sea", and including Niterói, Jurujuba, Icaraí, Itapuca and its many dozens of islands, such as Jurubaíba, Paquetá and Brocoió.[7]

The expansion of Brazilian cities followed a pattern of urbanization similar to that of nearly all countries under colonial rule. Notwithstanding an increase in the population of the original inhabitants, the indigenous people, for a long time the colony experienced modest foreign population growth, dispersed across small villages along the coast and inland mining settlements.

The Portuguese population rose slowly in the region around the bay, but the population made up of black slaves brought from Africa increased ever more dramatically. The figures for Rio de Janeiro show that, between the 17th and 19th centuries, residents of African origin far surpassed those of European origin, although the city's population was still modest when compared with the average population of European urban centers. The situation remained the same until the last quarter of the 19th century, when several laws culminating in the abolition of slavery in 1888 and encouraging immigration caused a veritable population explosion in Brazilian cities, especially Rio de Janeiro.[8]

Soon after the abolition of slavery, an enormous group of people became expendable and started to migrate from rural areas to urban centers, seeking new job opportunities. The main centers, although they already had some infrastructure services, were completely unprepared to accommodate this continuous flow of people. In the case of Rio de Janeiro, its population rose from close to 50,000 at the end of the 18th century to around 500,000 inhabitants in the mid-19th century and nearly 1 million at the start of the 20th century.

This process further intensified in the 1930s, with the start of industrialization, and grew even stronger in the 1950s, when the country definitively adopted a growth model based on industrial rather than agricultural development. The previous relationship between the countryside and cities became reversed, as the urban population surpassed the rural population. Cities, especially the largest ones, found themselves occupied by immense pockets of poverty. The new inhabitants, in the absence of alternatives, occupied areas considered risky and/or unhealthy, such as unstable slopes, the banks of rivers and flood plains.

One way or another, over the course of 500 years we have seen a slow but continuous process of land use and occupation, as if natural resources were infinite and all that abundance were eternal. Whole forests have been almost completely wiped out, like the Atlantic Forest, water systems have been altered, mountains have been flattened, mangroves and shorelines have been drained and extended, rivers have been canalized, and waste has been discharged into water bodies (such as lakes, lagoons and beaches). All this has had a predatory influence on nature, showing contempt for the characteristics of original sites and failing to take into account the importance of preserving their natural resources.

7 Lysia M.C. Bernardes and Maria Therezinha de S. Soares, "Rio de Janeiro: cidade e região", Rio de Janeiro: Biblioteca Carioca, 1987. 8 Francisco S. Verissimo et al., "Vida urbana: a evolução do cotidiano da cidade brasileira", Rio de Janeiro: Ediouro, 2001.

But could history have taken a different course? Could humans, who throughout this time considered themselves to be at the center of the world, intoxicated by their capacity to expand their territorial conquests and accumulate wealth, have changed direction or been replaced by another being, more concerned with the Universe's harmony? Did people still not realize that the nature they were using to progress, adjusting it to their vision of the world, was in fact a complex, fragile and diversified system whose balance, when irremediably broken, could result in huge losses for productive systems and, above all, serious threats to their own survival?

Dominating humankind imposed itself on nature, but it is important to remember that, despite being confined to small groups of scientists and scholars, some issues related to environmental imbalances have been studied for centuries. Theophrastus of Eresus, who died in 287 BC, the immediate successor to Aristotle, is believed to be the first person to be concerned about ecology, although this word was only used around 1,600 years later. It was he who first described the relationships between organisms and with their environment.

Many centuries later, new studies were conducted. In the 17th century, for example, people undertook important research into how species succession occurs after vegetation is burned. Following many studies carried out across the world, there gradually emerged the idea that there do not exist separate communities of plants and animals, but rather that all of them form, in an integrated manner, a unique and singular living system. According to the Encyclopaedia Britannica, it was only in 1866 that the term ecology was finally coined by German naturalist Ernst H. Haeckel to designate the "science of interactions", a concept that many years later was expanded to the "science that studies the relationships between living beings and with the environment" or the "sociology of nature."[9]

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9 Eliane Canedo de F. Pinheiro, *Baía de Guanabara: biografia de uma paisagem,* Rio de Janeiro: Andrea Jakobsson Estúdio, 2005.

Much later, however, only in the second half of the 20th century, the topic of ecology entered the public domain and joined the list of concerns in almost all countries. And this only happened because, associated with the highly desired progress of civilization brought about by technological advances, the intense industrialization process and the advantages of the urbanized world, clear signs of environmental imbalances started to be perceived, whose damage, going beyond political and territorial boundaries, affected whole regions until taking on global proportions.[10]

It was in this context, at the time still very nascent, that the first United Nations Conference on the Human Environment was held in 1972 in Stockholm, Sweden. Bringing together representatives of all countries, the summit managed to draw attention to the risks the planet would face if environmental issues were not made a priority, not just by political leaders but together, throughout society.

This initiative had almost immediate results. Many topics, such as atmospheric pollution, acid rain, climate change, the desertification process, contamination of rivers and oceans, and the nuclear threat, previously only discussed by a minority, now started to appear prominently in the media, at universities and in protests by environmental groups. From this point on, issues related to the environment expanded to everyday discussions, becoming ever present in modern life and forming part of politics and government issues, such as electoral platforms and public policies.

Having recalled this long history, we should return our attention to Guanabara Bay, striving to perceive everything from the movement of its waters to its nuances of color. If we observe it very calmly, we may notice a slight ripple on the surface of its waters, indicating the proximity of a school of fish. With luck, we may see flocks of birds flying over the region, looking for fish to feed on. Looking along the banks, we can imagine what it must have been like in the past, occupied in turn by Indian huts, fortresses, colonial villages and so on, until arriving at the megalopolis in which we live today.

Yes, it is worthwhile devoting attention to Guanabara Bay. Despite having suffered numerous attacks arising from the process of colonization and urbanization begun in the 16th century, it bravely resists. Still maintaining its majesty, it manages to be generous enough to perform its role of hosting Brazil's second most important port – a motor of economic activities generating work and income for the state's people. Remaining alive, it carries out its function of breeding marine fauna and flora, providing a livelihood for many families of fishermen that live along its shores. It also democratically offers some corners of its landscape to anyone who wants to rest in the shade of a tree or sunbathe on its beaches.

There are many factors that make Guanabara Bay much more than a mere geographical feature with which we live in an indifferent manner, not noticing that it, as a living, breathing body, is getting sick, slowing losing its charm, and it may wither away.

It is important to learn more about this place, relive its history, and understand how the mechanisms by which nature functions are complex and fascinating, because this place, this history and this environment determine the lives and future of the people who live and work there. The bay reflects the living conditions of the society around it. Fighting for it to become bright, luminous and full of life once more therefore means investing in our tomorrow. ●

10 *The Study on Recuperation of the Guanabara Bay System: Main Report.* Kokusai Kogyo Co, mar 1994.

LIVING WITH MICROORGANISMS

BY HENRIQUE LINS DE BARROS

There are more than 7 billion of us human beings, living on Earth's surface, our only habitat. Despite our different genders, beliefs, cultures and habits, we are all equal, while each of us is also unique. We are capable of adapting to changes and feeling the stimulations of the environment in which we live, and although we say we have just five senses (seeing, hearing, smelling, touching and tasting), in fact we have many more. We may not perceive this consciously, but in some way we feel nuances. It is said that our eyes are sensitive to a range of colors going from deep red to violet, the "seven colors" of the rainbow, but our body feels infrared and ultraviolet radiation. Our auditory system, like our sense of smell, touch or taste, is extremely sensitive and gives us information about the environment around us. We are in constant interaction with the world, exchanging matter, energy and information.

Every living being that inhabits Earth is connected to the world around it. There is no life without a relationship with everything else. The human body is not isolated from the environment in which it lives, and it needs it to maintain its individuality. Like all beings, humans are altering the world, and to remain alive they need to adapt their body and maintain their integrity in a constantly transforming environment. Thus, the human body also lives in a state of permanent internal imbalance, or rather dynamic equilibrium. **We have** trillions of cells, which developed from a single initial cell, fertilized when a sperm found an egg, transforming it into a zygote. All the cells in our body, which are constantly being renewed, come from this zygote, this primordial cell.

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Cada um de nós é o habitat para um grande número de organismos microscópicos (microrganismos ou micróbios), que habitam nosso corpo e são vitais para nós. Sem eles não viveríamos, pois eles regulam muitos de nossos processos fisiológicos. Cada um desses microrganismos mede cerca de um milésimo de milímetro de diâmetro – um volume cerca de mil vezes menor que o de uma de nossas células –, mas a quantidade deles num ser humano é tão grande que pesa em torno de dois quilos.

Esses diminutos organismos produzem proteínas indispensáveis para a nossa sobrevivência, participando da digestão de várias substâncias e favorecendo o nosso sistema imunológico. São eles que produzem vitaminas do complexo B-12, fibras solúveis; são eles que limpam nossa pele, os olhos, e estão presentes em vários outros processos vitais. Todo dia eliminamos bilhões desses microrganismos e os substituímos por outros, uma vez que a taxa de crescimento deles é espantosamente alta. Essa enorme população de bactérias, arqueias etc. constitui o nosso "microbioma", o nosso ecossistema interno. São milhares de espécies diferentes que convivem conosco, distribuídas em diferentes partes de nosso corpo, como a boca, o nariz, os ouvidos, a garganta.

Tiny organisms produce proteins that are indispensable for our survival. (...) Every day we eliminate billions of these microorganisms and replace them with others, given that their growth rate is astonishingly high. This enormous population of bacteria, archaea and so on constitutes our "microbiome", our internal ecosystem.

These microorganisms have played an important role in the history of evolution. Life on Earth arose millions of years after the planet cooled down, 3.4 billion years ago, based on a combination of existing chemical elements. There is not one specific element for life, but rather the organization, in a favorable environment, of complex molecular structures. The first organisms were microscopic and unicellular: the precursors of bacteria, they were capable of metabolizing inorganic elements, transforming them into complex molecules. Around 1.5 billion years ago there arose the first multicellular organisms. Thus, the evolution of life occurred through many leaps of growing complexity.

This history is punctuated by various periods of mass extinctions, which threatened life on our planet.[1] The best known, although not the biggest, occurred around 65 million years ago, putting an end to the reign of the dinosaurs, possibly due to the impact of a meteorite in the Yucatan Peninsula, in Mexico. Other extinctions took place on many occasions, but their causes are not fully known. It is estimated that changes to the environment have been due to volcanic activities, earthquakes, temperature rises or falls, reductions in the amount of oxygen in the oceans, and continental drift, which has radically altered the planet's surface, resulting in new environments unsuited to some species, which have been unable to adapt. Many hypotheses have been proposed, including one that concerns changes in Earth's magnetic field.

Earth has a magnetic field that protects it from electrically charged particles from the Sun, which hit the planet (solar wind). This field serves as a shield; without it, Earth would suffer the effects of this radiation in an intense manner, and life on its surface would not be possible.

The discovery of bacteria that produce tiny magnetic crystals and orientate themselves in the direction of Earth's magnetic field provides an example of interaction between living beings and environmental conditions. Work in this area has shown that multicellular bacteria exist, which supports the idea that evolution has taken place in leaps and bounds toward increased complexity of biological organization, essential to the maintenance of adaptive conditions.

We are immersed in a world of varied stimuli, and our biome adapts to its environment to maintain our health. Accordingly, we feel the variations of different factors that interact with us, and Earth's magnetic field may be giving us important information for our dynamic equilibrium.

Research carried out using large telescopes, space probes and other sophisticated instruments has shown the existence of a hundred planets that orbit stars far from the Sun, many with characteristics similar to those of Earth. These observations lead to the hypothesis of finding life in other worlds. Organized structures, capable of duplicating themselves, metabolizing and maintaining their form, despite environmental uncertainties, may look very different from the ones we know, and they may be considered alive – but in another life.

Every time we delve into an area of knowledge, a new field of greater complexity opens up, in a sequence that seems endless. The very origin of life on Earth is an open question. According to some researchers, given favorable conditions, life emerges in a short time. According to others, life is extremely complex and does not arise at random from a combination and organization of available elements, and so it is not easily produced.[2]

One of the fundamental issues is that we do not know how to characterize a living organism. It is immersed in its surroundings and fights to maintain its individuality.

1 Henrique Lins de Barros, "Biodiversidade em questão", Rio de Janeiro: Claro Enigma/Fiocruz, 2011. 2 Compare with Charbel Niño El-Hani and António Augusto Passos Videira (orgs.), "O que é vida?" Rio de Janeiro, Relume Dumará, 2000.

After a long history, many species have disappeared, giving way to others, as the environment was no longer suitable for their existence. Life goes on, however. It is the great diversity of life forms that guarantees their continuity.

We therefore do not know how to define what life is. In the view of some researchers, it is a system capable of renewing itself, regulating its own composition and conserving its limits.[3] In other words, a living being is a system that maintains its individuality during its existence, despite changes in the environment. Thus, after a long history, many species have disappeared, giving way to others, as the environment was no longer suitable for their existence. Life goes on, however. It is the great diversity of life forms that guarantees their continuity.

We, who call ourselves *Homo sapiens sapiens*, appeared on Earth less than 100,000 years ago, which is very recent if compared with many other animal species that have inhabited the planet for tens of millions of years. In recent centuries, since the second Industrial Revolution, changes in the environment caused by the indiscriminate use of technologies have caused alterations in the composition of air and waters, the temperature regime, and the incidence of solar radiation that reaches the planet's surface, and which could lead to an environment that is unsuited to us, jeopardizing our survival. Perhaps we are condemned to be one of the species with a short time of existence.

Although we may state that we are individuals, endowed with a single body, we also need to remember that we are a combination of many organisms that are invisible to our eyes, which sustain us. The microbiome that each of us is also adapts to external conditions and is constantly changing, in a dynamic, mutable and elastic process, but one that has its limits. If the world that surrounds us undergoes larger alterations, we may stop being viable. That is what life on Earth is like: it tells us a story, but we do not know what its end will be. ●

3 Compare with Lynn Margulis and Dorion Sagan, "O que é vida?", Rio de Janeiro: Jorge Zahar, 2002.

EVERY TOMORROW EMERGES FROM CULTURE

BY LUIZ FERNANDO DIAS DUARTE

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What does it mean to be human in the 21st century? To avoid having a restricted imagination of our near future, we need to incorporate an open, comprehensive and reflective vision of the broader context of the modern Western culture in which we live.

At its best, it depends on rationalizing the meaning of human experience, the expectation that systematic, continued and public reflection about everything that affects us can lead to broader horizons of the human condition than those we are all used to.

Science has been the main path for this systematic reflection since the 17th century. Since then, its information and proposals have sought the support of empirical experience based on a formal, universal rationality. This is relatively easy to do when it comes to the structure of the physical world and the functioning of the organic world – hence the rapid development of the technical-scientific system, i.e. the development of the physical and natural sciences dedicated to transforming the possibilities of knowledge and the human use of the world's resources.

It is not so easy, however, when it comes to the specific conditions of the social experience of human life, tangled in the complexity of thoughts, emotions, values and history. The humanities have developed more recently than the hard sciences because they have faced very peculiar challenges: they must understand how the symbolic and pragmatic conditions of life are organized and processed, in that which escapes the direct determination of the physical and organic fundamentals of human beings. The very status of this relative autonomy of thought, language, will, action and feelings is a matter of debate, because – for many scientists – all this could only be a direct, linear outcome of the biological properties of the subjects (as the mechanists once thought about the phenomena of organic life). The humanities explore and analyze the ways these "emerging" properties manifest themselves and function, i.e. those that, although they depend on the existence of underlying material reality, present specific characteristics, function according to their own logic, and involve the intervention of cognition, imagination and will in the course of history.[1]

In doing so, the humanities must confront another enormous challenge: its scope of analysis is not found in distant things, through the lens of a magnifying glass, a telescope or a mass spectrometer, but rather it is embedded in the immediate life of the whole of humanity (including both lay people and researchers). In the humanities, we study phenomena such as the family and kinship, religion and rituals, artistic taste and scientific disposition, the ways of doing politics and playing sports, health care and warfare, forms of sexuality and violence, the experience of time and the organization of space. Regarding all this, each culture and each social group has its own conceptions and procedures, which are often very different from ours.[2] It is by interpreting and comparing these forms of manifestation of exclusive human phenomena that we build sociological, anthropological, historical and psychological knowledge.

This knowledge is not easily convertible to technological apparatus and the construction of levers for the future. Its greatest strength and utility lie in the criticism to which it gives rise, by revealing how human projects are linked and how they are carried out, in contexts of hierarchy or power, dialogue or domination, harmony or predation, acceptance or exclusion.

In the context of a commitment to future plans, the role of the humanities should be more to promote general awareness of conditions that trigger this or that transformation in human life than to offer technical or practical solutions for these challenges. The violent climate change that is already affecting populations across the world will certainly accelerate in the near future, given that we have not changed the way we are using energy resources, nor moderated our economic development and production conditions. However, the technical and scientific tools to tackle this challenge already exist and would be at our disposal, if global political awareness and the willingness to undertake a radical economic restructuring were to seem viable. The crucial factors to confront this crisis are therefore typically human, and broader than formal rationality might expect: national narcissism, class greed, competition for power, consumerism and hedonism.

1 Marshall Sahlins, "Cultura e razão prática", Rio de Janeiro: Jorge Zahar, 2003. 2 Roque Laraia, "Cultura: um conceito antropológico", Rio de Janeiro: Jorge Zahar, 1997.

The profound alterations in the biodiversity around us are evolving in the same process of climate change. The weight of human activity in the contemporary biosphere's evolution has even given rise to a proposal to define a new geological era: the Anthropocene. The disequilibrium caused by human action ranges from the extinct dodo bird to the hyper-contagious Ebola virus, exacerbated by contemporary technical and scientific power. What could counteract this? Only a change of values and a radical restructuring of the forms of human social reproduction could permit a less devastating tomorrow.

The characteristics of humanity's new reproduction conditions include the population's absolute growth and increasing longevity. It is clear that this phenomenon has so far depended on general technological and scientific developments, and above all those of biomedicine. However, it would not have reached its current proportions if it had not been pursued and promoted systematically by national policies since the 18th century, with the aim of expanding population size and quality of health – essential conditions for state prestige.[3] At current levels, immense challenges present themselves, surpassing the vanities of political power: the capacity for food, housing and sanitation; the maintenance of viable long-term social security systems; and public security – among many other challenges very close to us.

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Technical and scientific advances have led to a notable acceleration in the conditions of coordination between different human organizations units, permitting an intensity of social exchanges (economic, informational and cultural) absolutely incompatible with those of the past. It does not occur to anyone to reduce the importance of the advent of digital and virtual communication, which has catapulted the possibilities of communication to exponential levels. However, nor does it occur to anyone to minimize the increase in the production of differences and confrontations that has accompanied the trajectory of planetary modernization. This tension between moving closer and moving further apart is well known among anthropologists, who described it as the principle of social organization of African and Melanesian tribal societies back in the 1930s.[4] The challenge is to understand how this dynamic is processed in the contemporary world, in which the preeminence of the values of equality, dialogue and tolerance, which seemed to have been so widely recognized, is frequently denied. From the perspectives of politics, religion, race, and even popular art and culture, everything seems to conspire to produce confrontation and belligerence, while technical and rational conditions could make us wait for universal peace to prevail.

It is in this context of crucial challenges and uncertainties, which cannot be responded to through conventional scientific rationality, that the experience of the humanities could make some contribution – by pointing to the universal properties of the human condition, describing their culturally specific forms of presentation and suggesting which type of values could permit the enrichment of the conditions of human interaction in the coming decades. No magic solution or silver bullet is available for this, as the human experience does not change quickly, from water to wine. Everything in it depends on the original socialization of each generation and exchanges between successive generations, in a process that demands attention at every moment in the formation of each subject – he who is the grandchild and child of his ancestors, and the parent and grandparent of his descendants.

3 Michel Foucault, "A política da saúde no século XVIII", in "Microfísica do poder", Rio de Janeiro: Graal, 1979. 4 Alfred Reginald Radcliffe-Brown, "Estrutura e função na sociedade primitiva", Petrópolis: Vozes, 1973.

In a culture like ours, committed to individualistic and utilitarian values, it is ever more vital to ask: "How do we live together?" This question induces reflection about values such as freedom, equality, tolerance and solidarity – which are also, contradictorily, built in our culture.

In reflecting on the cultural conditions for constructing the future, there are three key categories, without which we cannot understand anything of human life: its variety, complexity and systematic nature. Cultural variety or diversity, (such as in forms of kinship and family), the complexity of relationships in which subjects are installed when they are born and the systematic nature of standards and processes in which these phenomena (which seem to us so private and singular) occur, are inseparable conditions from present or future social life. In our reflection, we can never overemphasize the value of human "interaction" (among people, and between people and their environments). In a culture like ours, committed to individualistic and utilitarian values, it is ever more vital to ask: "How do we live together?" This question induces reflection about values such as freedom, equality, tolerance and solidarity – which are also, contradictorily, built in our culture.[5] Certainly, not all cultures share these values of ours, but if properly applied, they can give rise to peaceful coexistence, useful to all – even among the differences that will continue to proliferate.

In short, understanding how it is that we come to "live together" involves thinking about the variety, complexity and systematic nature of forms of human association (the principles of symbolic, economic and matrimonial exchange, establishing the state of humanity, for example), interaction (natural languages, and different communication forms and strategies) and symbolization (cultural integration, the sharing of values, technical-magical invention, and artistic creation). And this cannot permit us to forget the construction of forms of "detrimental coexistence", the negative exchanges involved in conflict, violence, domination, and psychosocial suffering – phenomena as varied, complex and systematic as those of wellbeing (and much more frequent).

Nonetheless, it is only by addressing all of this – and many more things that our reason conceives and puts into practice thanks to social imagination – that the future to be designed may really be what we want (in other words, when we know a little more about how and why we want what we want). Based on systematic reflections about the emergence of tomorrow, the humanities may play a more significant role to make human will effective in the world. Our shared tomorrow depends on the values, feelings and cultural dispositions that make humanity, here and there, inherit, invent, distort, destroy or improve this or that instrument, resource, weapon, machine, gadget, idol, toy... ●

5 Louis Dumont, "O individualismo: uma perspectiva antropológica da ideologia moderna", Rio de Janeiro: Rocco, 2000.


UNDERSTANDING
Anthropocene
TODAY
GLOBAL IMPACT
ALTERATION OF BIODIVERSITY
CLIMATE CHANGE
SILTING OF RIVERS
ALTERATION OF ATMOSPHERE
WHERE ARE WE?
HUMAN EXPANSION
DEMOGRAPHIC AND LINGUISTIC EXPANSION
EXPANSION OF CONSUMPTION
GROWTH OF CITIES
KNOWLEDGE

Never have so many changes occurred in such a short time: in the last 250 years, the transformations experienced by the world have been larger than those recorded in the 200,000 years since the appearance of *Homo sapiens*. Our species is the pivot of this movement summed up by the term “the great acceleration.” There have been just a few hundred generations since the mastery of agriculture and rise of cities, but in that short time we have managed to become a group of billions of individuals, using natural resources on a growing scale and generating an immense amount of waste. The impact of our presence has proceeded in a very unequal way: few people consume a lot, while many people consume little. According to scientists, our species’ capacity to affect the Earth system on a global scale characterizes a new geological era for the planet: the Anthropocene. In this stage of the journey, visitors are faced with a monument consisting of six standing stones, whose surfaces present a summary of the characteristics that define this new period of history, and inside four of them visitors can find more information about their causes and the evidence supporting them. We will not live on the same planet as our ancestors, but rather in a world profoundly modified by our own activity.

LIVING IN THE **ANTHROPOCENE:** UNCERTAINTIES, RISKS AND OPPORTUNITIES

BY JOSÉ AUGUSTO PÁDUA

In an interview given in 2005, at the age of 96, the anthropologist Claude Lévi-Strauss, of the French Academy, made an observation that captured in a very concrete way the dramatic singularity of the historic moment we are experiencing. Asked about the future of humanity, he responded:

> We are in a world to which I no longer belong. The world I knew, the world I loved, had 2.5 billion inhabitants. The world today has 6 billion human beings. And tomorrow's world, peopled by 9 billion men and women – even if this is the peak population, as we are assured in order to console us – prohibits me from any forecast.[1]

Lévi-Strauss' insight goes far beyond the nostalgia we might expect from an elderly man lamenting the present in comparison with the good times of his youth. Nor is it a message of generic nostalgia, which would fit different moments of history. In his view, he points out a much deeper issue: during his lifetime, the lifetime of a single individual, the world changed radically and will continue to do so in the coming decades. The speed and scale of transformations are so intense that any attempt at prediction is marked by uncertainty. Indeed, we are living at a time that is radically different from everything human beings have experienced so far.

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1 Claude Lévi-Strauss, "Longe do Brasil", São Paulo: Unesp, 2011, p. 57.

Population size is just one of the variables to be considered in this context, albeit a very significant one. The milestone of 1 billion inhabitants was reached globally around 1810, roughly 200,000 after the appearance of our species, so-called *Homo sapiens*. The population rose to 3 billion in 1950. This was more or less the world in which Lévi-Strauss lived, and which he deeply loved. As of 2005, when he gave his interview, the population was rising swiftly from 6 to 7 billion (between 2000 and 2010), and there were projections that it would reach 9 billion in 2050 and then possibly stabilize at this level (although some analysts talk of the possibility of there being 12 billion people by around 2100).[2]
However, as stated before, it is necessary to consider other variables. The population does not exist in a vacuum, but rather in the context of geographical spaces, economic and technological systems, institutions and cultures. The world that Lévi-Strauss loved, always taking 1950 as the benchmark, had around 40 million motor vehicles, the urban population was close to 30%, and there were 76 cities with more than 1 million inhabitants. At the moment, the number of vehicles is more than 1 billion, 54% of people live in urban centers, and 417 cities have more than 1 million inhabitants.[3]
It is important to note the systemic consequences of the new scales of human life on the planet. The production and circulation of vehicles, for example, consumes large quantities of steel, zinc, lead, rubber, aluminum and oil. The metabolism of large cities – which constantly interact, in material and informational terms, with extensive non-urban areas of agriculture, forestry and mining – involves colossal consumption of water, iron, wood and other renewable and non-renewable resources. The waste produced in urban areas, on the other hand, including enormous amounts of plastic, paper, organic waste and chemical substances, returns to the planet's ecosystems, taking its toll in terms of ecological degradation. In general, the establishment of an urban-industrial civilization on a global scale requires the everyday renewal of gigantic flows of matter and energy. These flows cannot cease, because even if they were halted temporarily, this would generate a succession of crises endowed with different levels of complexity.

From the 1970s, people started to speak with more intensity about the multiplication of "environmental problems" in different regions of the planet (pollution, industrial accidents, spillages, and erosion of landscapes).[4] Today it is becoming clear that such problems should not be understood as isolated malfunctions or accidents. Rather, they represent symptoms or signs of something much deeper: we are living in a new phase of history, a change in the level of human presence on Earth. Explosive population growth, which led us to the current mark of 7 billion people, with a projected population of 10 billion people by the mid-21st century, is a historic and social reality that has lasted for a little over 200 years.

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2 Dan Smith, "The State of the World Atlas", Oxford: New Internationalist, 2013, p. 22-23. 3 Paul Crutzen et al., "The Anthropocene: Conceptual and Historical Perspectives", Philosophical Transactions of the Royal Society, no. 369, 2011, p. 844; "United Nations, World Urbanization Prospects – the 2014 Revision: Highlights", New York: United Nations, 2014, p. 13. 4 A milestone in the dissemination of this debate was the United Nations Conference on the Human Environment, held in Stockholm, Sweden, in 1972.

The idea of the "Anthropocene" – propagated since the start of this century by Paul Crutzen, a joint winner of the 1995 Nobel Prize in Chemistry – has turned into the main conceptual instrument for understanding this historic change. In an article published in 2000 in the International Geosphere-Biosphere Programme's bulletin, written in collaboration with Eugene F. Stoermer, Crutzen stated that the Anthropocene is a "new geological era" that emphasizes the historically recent "central role of humanity in geology and ecology."[5] In other words, the term may be understood as the era in which the human species is no longer an animal like any other, living by appropriating a relatively small fraction of the natural matter and energy flows existing on the planet, and becomes a global geological agent. Based on this change in level, the human presence has started to impact the "Earth System" as a whole, above all the atmosphere, biosphere (the set of living beings), the water cycle and some biochemical cycles on a planetary scale (such as the nitrogen, phosphorus and sulfur cycles).

It is important to place the emergence of the Anthropocene within the context of a global macro vision of human history. A comprehensive timeline has been proposed by historians such as John McNeill,[6] according to whom this new era may be seen in three stages.

The first stage goes from 1800 to 1945, with the formation of the industrial era. The energy base for this great transformation, which continues to be widely dominant in the present, was massive expansion of the use of fossil fuels (especially coal and oil). As a result, this new moment of history is called the "Fossil Fuel Age" by some. The extraction of fossil fuels located inside Earth permitted an enormous expansion of production forces, promoting simultaneous growth of unparalleled intensity in population, urban-industrial structures and consumption of natural resources. From the year 1800, when the industrial system began to expand beyond England, to the year 2000, global economic output increased 50-fold and energy consumption rose 40-fold.

It was the use of fossil fuels, in fact, that made it possible to go past the scales to which human presence on the planet had previously been restricted. The growth of the human population on Earth therefore cannot be seen as a regular, homogeneous and merely cumulative process, i.e. as a purely biological process. It experienced radical breakthroughs related to major changes in the socioeconomic, technological and cultural fields.

However, it is important to note a second phase of the Anthropocene, which started around 1945 and is still in full force. It has been called "the great acceleration." This phase was gestated in the context of the period following the Second World War, when the availability of abundant, cheap oil – associated with the rise of Arab producers – was crucial to the dissemination of innovative technologies. This process resulted in an explosion of mass consumption (of automobiles, telephones and televisions). Subsequently, new technological waves continued to contribute to the further expansion of consumption on a large scale, such as computers and cell phones. Some of the indicators of this "great acceleration" were discussed above, as they precisely express the transition from the world that Lévi-Strauss loved to the world he no longer recognized.

5 P. Crutzen and E. F. Stoermer, "The Anthropocene", IGBP Newsletter 41, May 2000, p. 17-18. 6 P. Crutzen et al, "The Anthropocene: Conceptual and Historical Perspectives", Philosophical Transactions of the Royal Society, no. 369, 2011, p. 847-856.

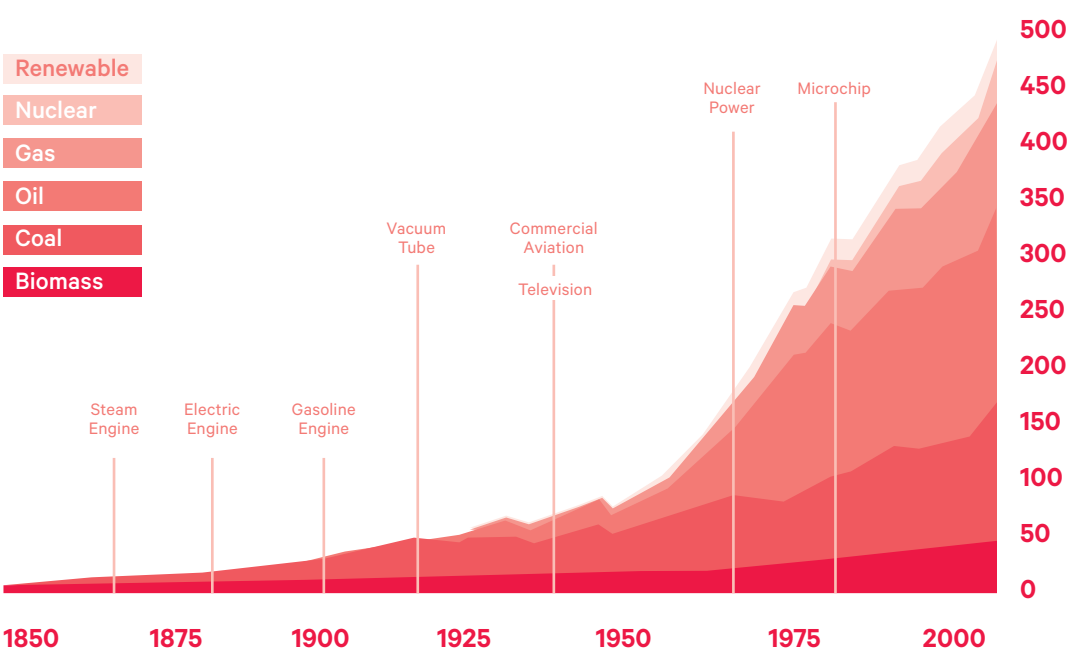
With regard to the history of the industrial or fossil fuel age, whose structural foundations remain in place, the "great acceleration" phase is notable for the enormous quantitative expansion in production and consumption (and the consequent qualitative change in the human presence on Earth). The image is like a gale that unfolds into a hurricane: the winds of the industrial revolutions – which already represented a great change in relation to preindustrial standards of production and consumption – became squalls capable of radically multiplying the social and environmental consequences of human action. The concentration of CO2 in the atmosphere is a clear indicator of this change in the Anthropocene's rhythm: growth was relatively modest between 1900 and 1957, rising from 297 to 316 parts per million (ppm). By 2010, however, the figure had risen to 395 ppm![7]

A summarized vision of this change in level that occurred in the mid-20th century can be seen in the following chart of global energy consumption between 1850 and 2009.[8] One may observe the extraordinary rise in energy consumption as of 1950, driven by the explosion in the use of oil and the arrival on the scene of new sources (such as nuclear energy and growing use of hydropower). However, it is important to note that, in the context of the "great acceleration", even sources that strongly marked the past – such as biomass in the pre-industrial world and coal in the industrialization processes of the 19th century – continued to present significant growth in consumption over the course of the 20th century.

Given this radical set of changes, what challenges present themselves for the future of humanity in the age of the Anthropocene? This is where a third phase, which could be called the "self-aware Anthropocene", comes in. This would be the moment when global public opinion, in the context of the very emergence of the concept, could recognize that there has been a change in the scale of human presence on the planet. Recognition of the risks inherent to this change – which manifest themselves, for example, in the potential dramatic consequences of global warming and loss of biodiversity – would demand a conscious discussion about our future. It would be necessary to reflect collectively about the new ethical responsibility of human beings, while we look for possible paths to sustainability and social development in the different socio-economic and cultural contexts existing in the world. There is no single, monolithic solution. The realistic and lasting confrontation of the global crisis needs to involve the intelligent coordination of a variety of strategies and policies.

7 Christian Pfister, "The 1950s Syndrome and the Transition from Slow-Going to a Rapid Loss of Global Sustainability", in Franck Uekoetter (org.), "The Turning Points of Environmental History", Pittsburgh: University of Pittsburgh Press, 2010, p. 90. 8 United Nations, Department of Economic and Social Affairs, "The Great Green Technological Transformation". Available at <www.un.org/en/development/desa/policy/wess current/2011wess.pdf>. Accessed on September 26, 2015. 9 Idem.

HISTORY OF GLOBAL ENERGY CONSUMPTION BY SOURCE[9]



It also needs to be clear that this third phase represents a desire or possibility above all. In concrete terms, we are living in the midst of the "great acceleration." The total volume of goods transported across the oceans, including grains, oil and minerals, increased from 2.6 billion metric tons in 1970 to 9.1 billion metric tons in 2012.[10] Furthermore, taking into account that the risks of the "great acceleration" are becoming ever more present in international discussions, especially in the environmental field, it is also notoriously difficult to create and implement institutions, laws and policies that are truly effective at achieving sustainability. Nevertheless, although it is not a dominant reality today, this next phase is already being nurtured through numerous meetings, studies and debates that are multiplying across the planet in the pursuit of a sustainable future – and also in the countless conflicts related to the resistance of communities or social groups to the advance of environmental devastation. One positive fact is that this mobilization is not limited to resistance, but also promotes a large number of social projects and experiments aiming at sustainable forms of living and working.

Thus, we need to recognize that we are facing realities and problems that are completely unprecedented. For this same reason, the political solution to the new situation is still shrouded in uncertainty. This is the case with doubts raised by the international scientific community about the pace and biophysical consequences of global warming – even though the overwhelming majority of scientists recognize that it exists and that human action plays an important role in its manifestation.

The great objective that presents itself for the future is the joint tackling of the environmental and social inequality crisis on a planetary scale. Thanks to strong progress in collecting and processing information, we now have a very accurate picture of the unequal reality of human societies. There are different global castes when it comes to the consumption of goods, resources and energy. Every year, a group of 2 billion people with very high or high income consumes more than 80% of the natural resources transformed into economic goods, while 4 billion people live in poverty and 1 billion live in miserable conditions.[11] Untying the knot of this unsustainable inequality, while carrying out the structural, technological and existential reforms needed to tackle the global environmental crisis, will be the major challenge of the coming decades.

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10 United Nations Conference on Trade and Development, "Review of Maritime Transport 2013", New York and Geneva: United Nations, 2013, p. 7.
11 "The World of Seven Billion Map", National Geographic, March 2011.

Faced with the combination of so many social and environmental crises we now see in the world, the potential for chaos and the unraveling of the international order is very concrete. Nevertheless, there are new possibilities and factors that could modify the terms of the equation: one of them is what sociologists such as Anthony Giddens and Ulrich Beck call "reflexive modernization."[12] One of the key points of this concept concerns the ever higher number of literate people associated with the speed of communications media and the establishment of numerous spaces for the meeting of opinions – elements that have contributed to the formation of societies increasingly capable of discussing their present and future, both on the international level and inside each country and region. There have never before been so many people able to read and write, who can readily process information and participate actively in discussions about the fate of societies. On a global level, 82% of the population is considered able to read and write, albeit to a rudimentary extent in many cases. Among the 1 billion wealthiest members of humanity, the literacy rate is 98%. However, to many people's surprise, basic literacy is already 66% among the 1 billion poorest people.[13]

This striking increase in the circulation of information and human capacity to incorporate it into thought and action is one of the positive aspects of the contradictory historic process that gave rise to the Anthropocene. Perhaps it is also a decisive as well as unprecedented factor for the establishment of a new international political dynamic.

The collective conflict of humanity with the planet, even if differentiated by classes and regions, is a new reality and a challenge that puts us at the crossroads of our own history.

Given the advances in knowledge production and technologies for storing and distributing information, we can today speak of "humanity" in a much more concrete way than the first philosophers of modernity (such as Locke, Smith and Marx) did. We can know, much more accurately, how we are distributed across the planet's space; where the rich, poor and destitute are; how the technical tools and consumption of energy and matter are divided among individuals and social classes. Moreover, notwithstanding all the uncertainties, we have access to much more accurate knowledge about the planet's ecological systems and the potential consequences of our actions.

The collective conflict of humanity with the planet, even if differentiated by classes and regions, is a new reality and a challenge that puts us at the crossroads of our own history. In the time in which we live – and especially in the coming decades – we need to take crucial decisions for the future of our species. The possibility of facing this task in a conscious manner may represent a great improvement in quality in the establishment of a new politics, both at an international level and within different countries, enabling us to meet the ethical challenges that living in the Anthropocene poses for the whole of humanity. ●

12 Anthony Giddens et al., "Modernização reflexiva", São Paulo: Unesp, 2012. 13 "The World of Seven Billion Map", op. cit.

HUMAN BEINGS FOR ALL TIMES: THE IMPERATIVE OF SUSTAINABILITY AS A PATH TO **A POSSIBLE FUTURE**

BY SÉRGIO BESSERMAN

Sigmund Freud once said that humanity grows when it falls from its pedestal; when its pride is wounded.[1] According to him, this occurred with Galileo Galilei (Earth is a small dot among billions and billions of galaxies), Darwin (we are a part of the history of evolution through natural selection) and himself, Freud (our unconscious drives us more than our conscious mental processes).

Stephen Jay Gould, a great paleontologist and popularizer of science in the 20th century, added: "Now it is time for us to fall from another pedestal, with the discovery of long time."[2] Indeed, humanity is very powerful in its short time, but does not have any power in the long time scale of nature or the extremely long time of the Cosmos. In the planet's timescale, hundreds of millions of years, humanity is completely powerless to generate significant harm to nature. To illustrate this, just remember that 65 million years ago, when the asteroid fell on the Yucatan Peninsula in Mexico, striking the final blow in the process of species extinction that began some millions of years earlier, it generated an impact many times greater than the entire nuclear arsenal existing today.

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1 Sigmund Freud, "A pszihoanalyzis egy nehézségéről" ["A difficulty in the path of psychoanalysis"], Nyugat, Budapest, January 1917. 2 Stephen Jay Gould, "Conseguiremos concluir a revolução darwiniana?", in "Dinossauro no palheiro", São Paulo: Companhia das Letras, 1995.

However, that was not the only loss of biodiversity on a large scale in history: of the many ones to have taken place, five are known as the mass extinctions. The one we just referred to was the mass extinction at the end of the Cretaceous period,[3] famous for having had its main cause discovered – the asteroid – and also for the known end of the dinosaurs (except their flying descendants, the birds). Now, if we compare the destructive powers of humanity to the great extinction at the end of the Permian period, for example, which around 235 million years ago caused the disappearance of 10% of marine species and 70% of land vertebrates, we can note how human power is even weaker in relative terms.[4]

Furthermore, if we add in the fact that we are at the top of the food chain, we can easily deduce what humanity's fate would be in the hypothetical case that it were to witness such an event. Despite all the strengths and powers we have at our disposal today, we would certainly not survive. Accordingly, even though humanity has developed a naive sense of omnipotence, thanks to the increase in its power over nature, on a long time scale *Homo sapiens* does not have the power or capacity to generate notable harm for the planet. At most, we would provoke another mass extinction, at the end of which a new era, with a new biodiversity, would arise. (Nature's recovery time after each of the five great extinctions is calculated to be between 5 and 10 million years.[5])

Environmental awareness and concern should not therefore be seen as merely the consequence of a paternalistic stance in relation to the natural world, but on the contrary the result of recognition of our helplessness and dependence on the home where we live, Earth.[6] The risk of extinction that hangs over the future relates less to the planet's nature than to humanity.

If we ask ourselves what the extent and depth of the risk faced by civilization is, the answer is limited: as far as we can know, we are not likely to suffer an apocalypse or insurmountable catastrophe. However, it is precisely because we are not certain of this that we cannot afford to be complacent.

Uncertainty ought to be a sufficient indication that we are on an unsustainable path for the development of the human species. An evaluation that would allow us to know whether or not humanity's current course is sustainable should be made in the context of a risk analysis essentially the same as the one all people make in their everyday lives, or the one that business people use to take decisions related to their businesses.

The prospect of unsustainability would be confirmed not only by what we know, but above all by what we do not know. Within their known dimension, statistics make the environmental crisis of the 21st century evident. Indicators suggest scenarios with a strong tendency for degradation of the capacity for natural renewal of services fundamental to human quality of life (climate, fresh water, fertile soils and biodiversity) at a speed consistent with the envisaged rates of their usage.

However, we know little about the release of methane that global warming could cause in the frozen soil (permafrost) of Siberia, which contains immense stocks of this powerful greenhouse gas. Nor do we have a deep understanding of the dynamics of the ice sheets of Greenland and Antarctica, which are crucial to scenarios of rising sea levels. Likewise, we are ignorant about the resilience of the current ecological balance and the brutal rate of species extinction. As we can see, we may be generating irreversible processes that will have potentially disastrous consequences for civilization and human species. To any rational mind, the precautionary principle is the applicable imperative.

On the other hand, it may be said that the current development model is unsustainable, because not only do we not know the true meaning of the concept of "sustainable development", but we are also unaware of how to measure the notion of sustainability with precision. Many important efforts are under way to find better ways to measure the idea of sustainability. Measurement of countries' gross domestic product (GDP) has been relentlessly criticized for its major weaknesses. The insufficient and misguided way in which natural resources are considered in national accounts is one of the main grounds for this criticism. The United Nations Statistical Commission has also been working with national institutions to develop a family of sustainable development indicators. Many composite indicators and other ways of evaluating the sustainability of current development are being enhanced.

3 The Cretaceous period was the last period of the Mesozoic era. It began 145 million years ago and ended 65.5 million years ago. 4 Peter Ward, "O fim da evolução: extinções em massa e a preservação da biodiversidade", Rio de Janeiro: Campus, 1997. 5 Ibid., p. 321. 6 Sérgio Besserman, "Darwin e a consciência no século XXI", in "Charles Darwin: em um futuro não tão distante", São Paulo: Instituto Sangari, 2009.

For these reasons, deep reflection about the term "humanity's sustainable development" is the most precious thing that human beings could now have in their hearts and minds. It is up to us to contextualize all parts of this term – humanity, sustainable and development – given that the concept still sounds like a rich unknown thing to be explored.

Regarding the term "humanity", we should remember that it only exists in the abstract. What exists in concrete reality and is part of *Homo sapiens*' constitution, including genetic, is clans, tribes and nations. A person who thinks, takes decisions and acts on the basis of humanity's long-term rather than immediate future will be a different human, reconstructed by culture in relation to the humans of today.

When it comes to "development", we note that the identification between this term and quantitatively measured economic growth was merely the product of a historic age that is now being superseded. The inclusion of broader objectives in human perspective, as expressed in the Human Development Index system (created by Amartya Sen, the winner of a Nobel Prize in Economics), is a great step forward, but it still does not incorporate the greater challenges of the issue of sustainable development.

Finally, the meaning of "sustainable" goes beyond something that merely lasts, as common sense tends to indicate, and means much more than a commitment to future generations. Like human consciousness, the term "sustainable" relates to time; not short time (that of the human species), but all times, including long time (that of the Cosmos). And what makes humans stand out from nature if not consciousness?

The omnipotence of a humanity that is still in its infancy and that does not, as a society, know the existence of limits needs to be overcome. Human civilization needs to be more "conscious."

Until recently, the life expectancy of human beings was low and our ecological impact was restricted in both space and time. In the period before the Industrial Revolution, when the first significant impacts of human action on the planet were seen, the consequences were local: unhealthy spaces, polluted rivers, contaminated air in cities. With economic growth, the consequences became regional: an entire water basin was harmed or a whole biome (such as the Atlantic Forest) was devastated. Around five decades ago, this scale changed and environmental aggressions became planetary. Now our impact is global and its consequences extend for centuries. Today, given the size of alterations to the planet's landscape arising from human actions, the term Anthropocene has been coined to designate the current geological era.

Although the last 300 years have experienced remarkable development, which has increased life expectancy, cut infant mortality, educated populations, reduced violence and greatly improved the wellbeing of human beings, we should be attentive to our numerous unsolved problems: the poverty of billions of people, enormous inequality, the persistence of frequent assaults on fundamental human rights, the existence of countries where there is no democratic freedom, and also the persistence of discrimination based on ethnicity, sexual orientation or ideas, including religious beliefs or their absence.

In short, in this appraisal, in which we weigh up extraordinary advances and unresolved key issues, we add another theme that will be at the center of 21st-century history: the global ecological crisis and the challenge of building a civilization founded on sustainable development.

Many important efforts are under way to find better ways to measure the idea of sustainability. Measurement of countries' gross domestic product (GDP) has been relentlessly criticized for its major weaknesses.

The choice is ours and it must be made now: either we will be a humanity that will remain in the excess and selfishness of its “childhood”, or we will expand our consciousness in time, generating a revolution of thought like the one that the Renaissance represented to history.

Because of the impact of the global ecological crisis on the world economy and above all on the wellbeing and freedom of people, especially the hundreds of millions who are the poorest, the most vulnerable and lacking the means to defend themselves, the human species will face challenges in the next two decades that may be considered unprecedented, if we bear in mind the timeframes in which our choices will be made. How much will we raise the planet’s average temperature in future (between 2 and 5 degrees Celsius)? Will we provoke immense climate change? What proportion (between 10% and 30%) of the species living on the planet will be made extinct forever?

The choice is ours and it must be made now: either we will be a humanity that will remain in the excess and selfishness of its “childhood”, or we will expand our consciousness in time, generating a revolution of thought like the one that the Renaissance represented to history.

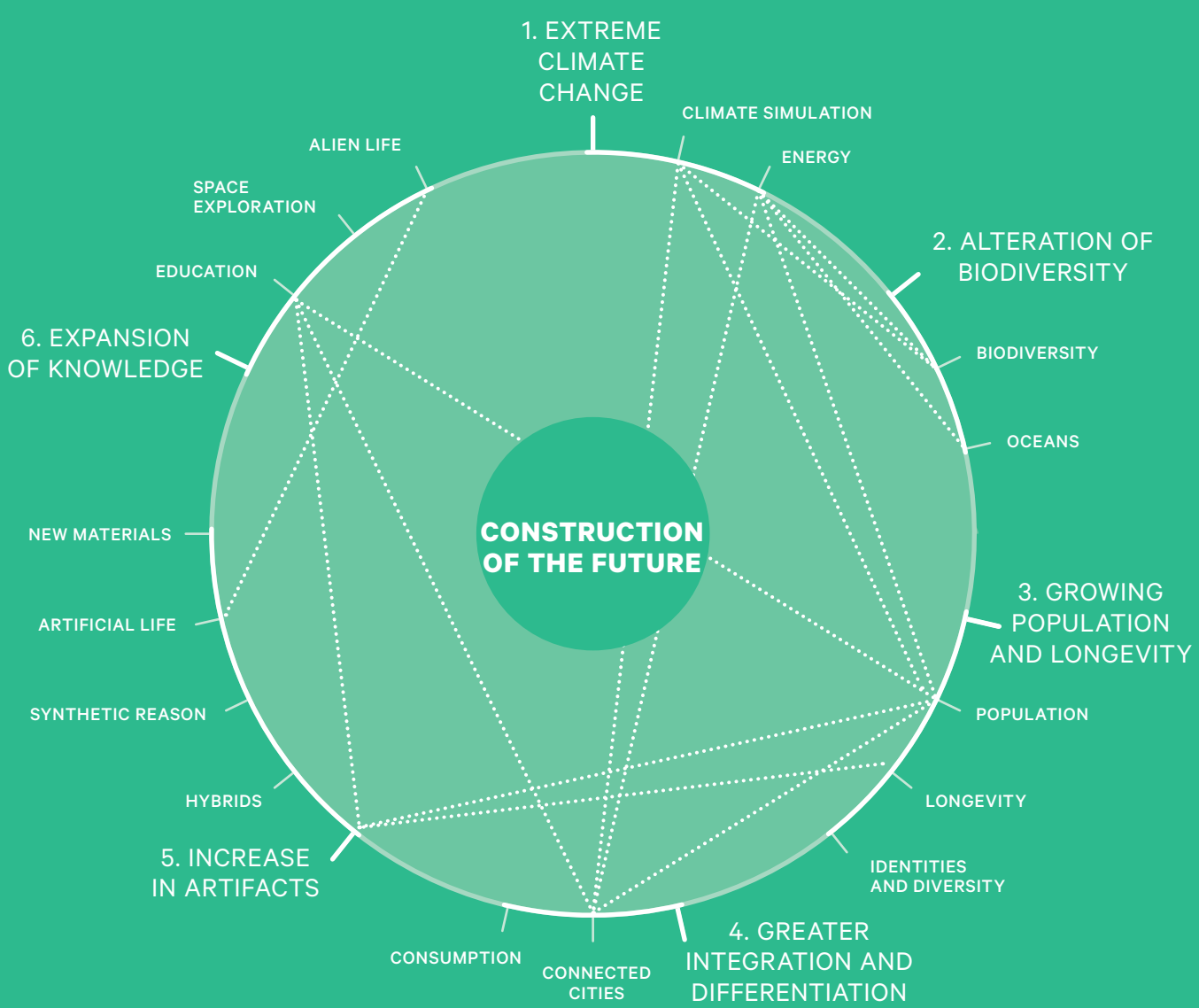
The concept of sustainability therefore takes us to the necessary expansion of the boundaries of time, the broadening of the temporal categories with which we tend to consider future generations, even the most distant ones. As the writer Jean-Claude Carrière famously observed, the term “development” is etymologically unambiguous in several languages.[7] To develop does not only mean to “expand, grow”, but rather to “undo what is involved”, or to “unroll what is rolled”, or in French and English (“développer/develop”) to “un-envelop.” It therefore involves a process in which a potential that is contained, stuck in certain circumstances of history, is freed. In other words, it means a process defined by time.

According to Saint Augustine, there are three times: the present time of present things, the present time of past things, and the present time of future things.[8] Our species is now faced with the greatest challenge of the 21st century: to construct human beings capable of being, seeing and acting in all these times.

The issue of sustainable development is consequently intertwined with the issue of human consciousness. The question “What is sustainable development?” could also be read as “Who are human beings?” And the answer to the question about what sustainable development could be may also answer the question of who will be the humans of tomorrow who human beings themselves will construct. ●

7 Jean-Claude Carrière, “Entrevistas sobre o fim dos tempos”, Rio de Janeiro: Rocco, 1999. 8 Santo Agostinho, “Confissões”, translated by J. Oliveira Santos and Ambrósio de Pina, “Os Pensadores” collection, São Paulo: Nova Cultural, 1996.

WHERE ARE WE GOING?



Tomorrows

What will the world be like 50 years from now?
Contemporary science permits us to identify some major trends that are set to shape our lives in the coming decades. We will be more numerous and we will live for more time on a planet with a changing climate and a less diverse natural environment. The oceans are likely to be the next agricultural frontier, but their basic biological systems already show worrying signs of wear. How will this paradox affect our lives? Our cities will grow, and cultures and peoples will be even more connected; for this same reason, groups will refuse this closeness and they will seek to reaffirm the fundamentals of their particular identities. Will we live closer or further away? Increasingly advanced, technical artifacts will become more abundant, more cooperative and more integrated with our bodies and minds. Will we still be the same people? The solar system excites our spirit of investigation and expansion. How would humanity receive the news that alien life had been discovered, organisms outside Earth? The choices we make each step of the way will determine the future scenario we will reach. Interactive games allow visitors to relate the impact of individual and collective decisions, and ethical and political choices about the conditions of life on the planet. How do we want to live?

NEW POPULATION PYRAMIDS: **THE CHALLENGING RECONFIGURATIONS** OF 1961 TO 2061, A CENTURY OF TRANSITIONS

BY ALEXANDRE KALACHE

The world is currently experiencing extraordinary demographic contrasts that will intensify over the next 50 years. Some countries will age at an unprecedented speed, while others will see their populations rise steeply. These dissonant realities will have impacts on all aspects of society.

In 1960, Norway was the country with the highest life expectancy at birth (73.49 years), followed by other Scandinavian and Northern European countries, Australia and Canada.[1] No other nations reached the symbolic milestone of a life expectancy of 70 years, which has now been attained by more 121 countries, most of which are considered to be developing.

At the moment, more than 25 countries have a life expectancy of more than 80 years, led by Japan (83 years).[2] According to projections, however, we can state that by 2060, some countries will have exceeded the 90-year mark, such as South Korea and Hong Kong. Other countries – including Japan, Switzerland, Singapore, Australia and Spain – will have children who, born 50 years from now, will be expected to live for more than 88 years on average.

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1 United Nations, Department of Economic and Social Affairs, Population Division, "World Population Prospects: The 2012 Revision", DVD Edition, 2013. 2 Idem.

With regard to life expectancy at the age of 60 years, in other words the average time people live after this age, it has also increased significantly in the last five decades. In 1961, a 60-year-old person did not live more than another 20 years in any country; today, they are expected to live for at least another 23.8 years in the 10 countries with the highest estimated figures, rising to 25.51 years in Japan.[3] Additional gains are certainly foreseeable, but given the progress of health technology (through the early diagnosis of non-communicable diseases) and ever more effective treatment methods (such as surgical interventions and new drugs), the projections for 50 years from now become particularly risky.
In 1960, there were no surprises among the ten most aged countries: all were located in Central and Northern Europe, with Norway in first place once more. By 2010, however, Japan had become by far the most elderly country in the world, with more than 30% of its population made up of people aged over 60, and relatively poor European countries such as Bulgaria, Greece, Latvia, Croatia and Portugal had also joined the top 10.[4]
One interesting comparative fact is that Japan was the first country in which the proportion of elderly people surpassed under-15s – a reality since 1960. Among other countries with large populations, Germany and Russia repeated this experience in 1980 and 2000, respectively. The United States is expected to reach this same proportion in 2015, followed by China (2025) and Brazil (2030) – while India will do so in 2055, the same year in which this experience is projected to become global.[5]

In contrast to the aging of the vast majority of the countries in which population growth over the next 50 years will be small or negligible, if not negative, the countries of the Middle East and Africa will continue to experience a rise in their populations – more than six-fold in some cases.

However, a country's aging does not only depend on the number of people who reach "old age" (60 years, according to the United Nations' definition). Its speed depends even more on the decline in total fertility rate (TFR), meaning the average number of children a woman expects to have at the end of her reproductive life. Fifty years ago, only five countries (Estonia, Latvia, Japan, Hungary and Ukraine) had reached a TFR of below the replacement level, 2.1 children per woman, meaning in practice that couples will not maintain their numbers. Around 1980, just 20 countries had this condition. At the moment, there are more than 80, and in 2060 it is estimated that the total will be 153 countries.
If today a growing number of countries (such as Japan, Germany, Italy, Spain, Russia and others in Eastern Europe) are concerned about their shrinking populations, in the 1960s the predominant discussion among demographers and society centered on the so-called "demographic explosion." This reversal of perspective has changed the ranking of the world's 10 largest countries in terms of population. Thus, Pakistan and Nigeria have replaced Germany and the United Kingdom on this list, and by 2060 Russia and Japan are expected to leave it, to give way to Ethiopia and the Philippines. Within the ranking, India is projected to overtake China as the largest country (and then to exceed its population by more than 300 million inhabitants), while Nigeria's population is set to more than triple, to 537 million. We should also mention the case of Ethiopia, which may come to have nearly as many inhabitants as Brazil, despite being much smaller in area.[6]

3 United Nations, Department of Economic and Social Affairs, Population Division, "World Population Prospects: The 2012 Revision", DVD Edition, 2013. 4 Idem. 5 Idem. 6 Idem.

In contrast to the aging of the vast majority of the countries in which population growth over the next 50 years will be small or negligible, if not negative, the countries of the Middle East and Africa will continue to experience a rise in their populations – more than six-fold in some cases. Comparing the demographics of the 10 sub-Saharan African countries with the highest populations in the 2010s with the projection for 2060, there is no doubt that this region's population rose nearly four-fold between 1960 and 2010, from just over 220 million to around 831 million.[7] In turn, the United Nations' estimates for this region in 2060 point to slightly slower growth, around three-fold, resulting in a total population of almost 2.5 billion. If this prediction is confirmed, the social, political and economic implications will be enormous, because precisely the poorest region of the world will be subjected to demographic pressures of immense magnitude.

However, a lot may happen in five decades, and just as people in 1960 did not predict such an accelerated decline in total fertility rates in so many countries, one may also speculate that the projections for Africa and the Middle East will not come true, as occurred with Brazil in recent decades and as some countries in these regions, such as Egypt, Tunisia, South Africa, Ghana and Botswana, have already indicated.

Not long ago, the aging process involved a very different story to the current one: developed countries first became wealthy, and then, over a longer period than we see today, they grew old. Countries such as Brazil, however, are aging very quickly and in a context of relative poverty.

Not long ago, the aging process involved a very different story to the current one: developed countries first became wealthy, and then, over a longer period than we see today, they grew old. Countries such as Brazil, however, are aging very quickly and in a context of relative poverty. A comparison with Canada shows this clearly. At the moment, 24% of Canadians are aged over 60, around two times higher than the rate in Brazil, but by 2060 this proportion will be higher in Brazil than in Canada.

In 1960, Brazil's total population was less than 73 million. Fifty years on, it had grown 2.5-fold to more than 195 million. The estimated population in 2060 is 228 million people – in other words, a rise of less than 20%. This reflects a sharp fall in total fertility rates. In 50 years, Brazil went from a demographic explosion to a situation of low population growth, and is set to start a process of population decline over the next 30 years.[8] At the same time, the proportion of elderly people rose from 5.4% in 1960 to 10.2% in 2010 – and should exceed the current levels of Japan (the most elderly country) before 2060, when an estimated 32.9% of Brazilians will be aged over 60. There will be an even more pronounced increase in the proportion of people aged over 80: from just 0.4% in 1960 and around 1.5% in 2010, the current projection is 9% in 2060. Accordingly, the proportion of Brazilians under the age of 15 will have fallen from 43.3% in 1960 to 14.5% in 2060.

7 Idem. 8 The TFR went from 6.2 in 1960 to 1.9 in 2005. The latest estimate, made in 2013, indicated 1.77, and current projections are that it will remain at this level until 2060.

An interesting point in Brazil's declining birthrate is the possibility that a new social model will be generated, valuing elderly people as qualified workers and promoting a revitalization of society. Growing old means becoming revitalized – provided that society permits this.
It is worth highlighting the concept of "functional capacity" or "functional age" as opposed to chronological age.[9] Reaching the age of 85 with vitality and productivity will be ever more common. According to the World Health Organization, active aging is the process of optimizing opportunities for health, continued education, participation and security so as to improve the quality of life as we grow older. "Elderly-friendly" cities should avoid the rapid decline in the number of individuals below the threshold of functional incapacity, by keeping people physically, intellectually and economically active for as long as possible. Intergenerational solidarity ought to generate a goal of productive longevity from childhood in order to obtain the best results in the third age (including protection for those who, for health reasons, fall below the functional capacity level). Having health and knowledge is a guarantee of full participation in community life.
Technology also has a decisive role in helping everyone with active aging and compensation for those who need support (whether concerning the use of devices that increase the level of capacity or genome manipulation, which could drastically reduce the number of people suffering from diseases such as Alzheimer's and Parkinson's). Thus, it is important to introduce the concept of Health Adjusted Life Expectancy (HALE), an indicator suggested by the World Health Organization. Unlike conventional life expectancy, which considers all years as the same, in calculating HALE, years of life are weighted in line with each individual's state of health and quality of life. After all, one must take into account that elderly people, as they have accumulated an enormous variety of experiences during their life, are more heterogeneous than, for example, a group of teenagers.

[9] Alexandre Kalache and Ilona Kickbusch, "A Global Strategy for Healthy Ageing", World Health, vol. 5, 1997, no. 4, p. 4-5.

In semi-desert regions, how can drinking water be provided to so many people? What contributions will technology provide – for example, by developing less expensive techniques for desalinating seawater?

Thus, numerous questions are posed for the coming years. What are the environmental implications of a sub-Saharan Africa with a vastly denser population? In semi-desert regions, how can drinking water be provided to so many people? What contributions will technology provide – for example, by developing less expensive techniques for desalinating seawater? This example suffices to illustrate the necessary interconnections between scientific and technological studies on the one hand and studies of population and the environment on the other. However, the list is much longer and we may ask ourselves what pressures there will be in regions that are already experiencing population decline in neighboring countries.
From a population point of view, how much of a rise will there be in the global number of immigrants, who in 2010 amounted to 250 million? If Japan, for example, were to adopt policies to proportionally stimulate the entry of as many immigrants per capita as Australia or Canada receive, what would its age pyramid look like in 2060? Will the economies of very aged countries continue to grow? What policies are needed for this to be put into practice? On the other hand, women are participating actively in the paid job market in a growing number of countries and their economies will come to depend more on this contribution. Will sustainability between countries become more interdependent? How can we develop and stimulate a culture of intergenerational social contracts and more cohesive societies?
One of the great contributions of the 20th century was to add more than 30 years to people's life expectancy in the majority of countries. The 21st century's contribution will be to bring a better quality of life to people of all ages. After all, we need to recognize that each country's population pyramid is not rigid and that demographics are not an inevitable destiny, but rather a current reality based on which we can create solutions aimed at good planning of the future. ●

CONNECTED CITIES: HUMAN POLLINATION

BY ROGÉRIO DA COSTA

The metaphors are numerous: cities like an anthill, maze, fortress, super-organism, brain, network of networks, chaos... Ultimately, they are all this at the same time, but in future they will need, above all, to be intelligent.

Over the course of history, large cities have organized themselves in the form of ever more complex networks and systems, as the result of the interconnection of people, commercial transactions, technologies and information. They are crossed by trade and transport networks, infrastructure, machines, and power and communication systems.[1] A quotation by the historian Lewis Mumford, in his book "The City in History", reminds us that urban clusters must inevitably be seen as "a structure especially equipped to store and transmit the goods of civilization."[2] However, these goods can only be produced because cities have become, in the words of the scientist Steven Johnson, a kind of interface that has enabled individuals to put their intelligences in contact, through a type of cross pollination.[3] This has allowed not just an expansion in the flow of ideas, but also the preservation of those that would be essential to the development of civilization. In the course of the first centuries of the ancient urban populations, it is possible to find inventions that proved to be crucial to the development of our civilization, such as the cultivation of grains, the plow, the potter's wheel, the sailboat, the loom, copper metallurgy, abstract mathematics, astronomical observation and the calendar. Cities store and transmit new ideas to the whole population, ensuring that, once invented, new technologies will not disappear.

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1 Federico Casalegno and William J. Mitchell, "Connected Sustainable Cities", Massachusetts: MIT Press, 2008. Available at <http://mobile.mit.edu>.
2 Lewis Mumford, "A cidade na história", São Paulo: Martins, 2001.
3 Steven Johnson, "Emergence", New York: Scribner, 2001, p. 107.

However, although cities may be seen as a source of resources and information, they are also a privileged space for living and interacting. It so happens that current patterns of economic growth have generated an enormous mismatch between individuals' ever rising demand for resources and information on the one hand, and on the other hand the capacity of cities' entire infrastructure to withstand this demand. This ends up impacting the various dimensions of life and the environment. Migratory processes, demographic growth, and the production, distribution and consumption of manufactured goods and materials and natural resources are factors that directly affect the equilibrium of cities. Alongside this, the management model for metropolises, based on centralized administration, has been the same for centuries. However, we can already see, above all in megalopolises, the exhaustion of the governance model that we know, given the complexity reached by this super-organism at the start of the 21st century, and consequently the enormous management challenges in all its human and material processes.

Cities have evolved from simple structures to complex organisms. However, these organisms, despite reaching the end of the 20th century with an advanced digital "nervous system", represented by information technology and the internet, have still not reached the metaphoric production of "thought." This means that cities, in the near future, will not only be capable of storing and transmitting information for their population of individuals – their "cells" – but they will also be able to form an idea about themselves, a kind of consciousness of their current state. Things, places, the atmosphere and transport are likely to gain a digital layer, which will display information about the way people are interacting with everything around them, and how each of these things may exchange signals to indicate their present status. As a result, they will have an ever lesser need (although a need nonetheless) for a centralized management system. They will progressively reach levels of self-management for various internal processes: the allocation of resources such as water and power, emissions of pollutants in the atmosphere, waste discharges in the environment, the movements of people around the city, and goods delivery logistics. At the same time, individuals may, in turn, be ever more aware of the effects of their actions on the city as a whole. They will be able to perceive the impacts caused by their personal decisions at environmental, social and political levels.

Examples of smart cities can already be found in some countries. One of them is New Songdo, a project under way in South Korea. In this city, currently home to 70,000 people, home waste flows directly through a network of underground tunnels to treatment stations. Cars have chips connected to a central system that detects when many people are taking the same route and takes measures to avoid traffic jams. Another example of a smart city is Dongtan, in China, a country where a projected 1.12 billion people will live in urban areas by 2050. Dongtan features renewable energy, zero-carbon-emission transport, and a water treatment and recycling system, among other sustainable initiatives. A third example is Masdar City, in Abu Dhabi, a city designed to be completely sustainable, with 100% renewable energy supplies, zero carbon emissions and an underground electric transport system.

However, although some future visions point to sustainable cities, with systems to self-regulate their processes spread everywhere, with green areas balancing built spaces, in short, with all the smart things it would be possible to imagine for an urban space, many reports from international organizations make very different predictions for the cities of tomorrow.

The migratory flows that are affecting the structures of cities and simultaneously making them multicultural are among the main factors set to contribute to the increasing complexity of megalopolises. According to figures from the Organization for Economic Cooperation and Development (OECD),[4] the world's population is expected to reach around 9.3 billion by 2050, with 97% of the population growth occurring in developing countries. In this same year, more than 70% of the global population will be living in urban centers. Migrants who cross frontiers in search of work and a better life may exceed 400 million in number, or 7% of the globe's current population, by 2050. This information comes from a report published by the Geneva-based International Organization for Migration (IOM).[5] IOM believes this increase is an inexorable and inevitable trend, and we are set to see growing numbers of people competing for few jobs in developing countries and fleeing from the effects of climate change.

Regarding the latter point, a report by the same organization claims that population movements have already begun and the numbers may be much higher than early estimates. There will be at least 200 million climate migrants by 2050, and possibly as many as 700 million, in the worst scenarios. If nothing is done, this could be the largest human migration ever recorded in history. Without heavy investments in areas linked to migration, such as housing, education and health services, the problems of integrating migrants in other countries will be more severe than they are now.

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4 Cf. OECD. Available at <http://www.oecd.org>. 5 Cf. International Organization for Migration (IOM). Available at <http://www. iom.int>.

All this human movement, the result of migrations caused by a variety of factors, ends up favoring the growth of metropolises and the formation of mega-regions or "endless cities", a phenomenon that now seems irreversible. Currently, more than half of the global population live in urban regions. As already mentioned, 70% of the population will be living in urbanized areas by 2050. Within this trend toward endless cities, according to a 2010 report by the United Nations Human Settlements Program (UN-Habitat) entitled "State of the World's Cities",[6] global megacities are merging to form vast "mega-regions" that can extend for hundreds of kilometers across countries, housing more than 100 million people. This could be one of the most significant phenomena regarding developments – and problems – in the way people will live and economies will grow in the next 50 years.

The largest mega-regions, which are at the forefront of the rapid urbanization sweeping the world, are as follows: Hong Kong-Shenzhen-Guangzhou, in China, where around 120 million people live; Nagoya, Osaka-Kyoto-Kobe, in Japan, which is expected to reach 60 million people in 2015; and Rio de Janeiro-São Paulo, a region with 43 million people in Brazil. The growth of mega-regions and municipalities is causing unprecedented urban expansion, the appearance of new shantytowns, unbalanced development and income inequalities, given that more and more people are moving to satellite or dormitory cities. This phenomenon, arising from urban agglomerations, is set to intensify over the next 40 years, as the trend of megalopolis formation is considered irreversible.

Finally, we must stress the complex cultural effects that population flows, together with the enormous urban expansion forecast for the coming decades, will bring about, enabling a broad cultural interconnection. A Unesco[7] report about trends in the 21st century identifies some important aspects that ought to be considered in the relationship between the planet's many different cultures. Intolerance, xenophobia, racism and discrimination reappear, sometimes in a violent or even genocidal manner, justified in the name of religious, national, cultural and linguistic affiliation.

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Urban growth, which should involve the majority of megalopolises and metropolises between now and 2050, may have huge impacts on urban life and the consumption of resources and goods, and also, from a social perspective, on access to work, the exclusion of minorities, and human rights. In these various scenarios for urban life in 2050, we should ask ourselves whether we are moving toward cultural and ethnic clashes or mixing. In the city of tomorrow, will there be a hegemony of one culture over others? Whether in smart cities or human anthills, we must always ask ourselves whether cities will favor cultural pluralism, dialogue and the meeting of cultures. ●

6 Cf. UN-Habitat, Relatório sobre Megarregiões. Available at <http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2562>. 7 Cf. Unesco. Available at <http://www.unesco.org>.

WHAT WILL WE BE LIKE TOMORROW?

BY BENILTON BEZERRA JR.

We are the only natural beings whose existence is not solely determined by norms and limits of a vital order, as we continually incorporate the effects of everything we do into our own nature. We create objects, technologies, moral values and cultural rules that configure the physical and social environment in which we live, expand the capacities of our organism and shape our subjectivity. As the material and symbolic conditions that sustain our everyday lives are altered, our perception of the world, others and ourselves also changes. What we are is constantly evolving, and this openness in our own nature is our core trait.

Some of the transformations that will affect us in the coming decades may be glimpsed on the horizon, and others may not. It would have been hard to predict the impact produced by the internet, for example, which in just a few years has profoundly changed our way of being in the world. Perceptions of space and time, the way we deal with information and memory, the organization of work, networks of our personal relationships, and the relationships between local and global, the individual and the collective are examples of patterns that have been profoundly altered by the relationship between people and technology.

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As occurs with all technology, of course, its effects are complex. On the one hand, the internet has transformed the world into a more accessible, shared and supportive place, but on the other hand it has also precipitated the emergence of new forms of violence, crime, control and oppression – digital attacks on security systems, cyber espionage, scams targeted at individuals and state censorship of information, for example.[1] Accordingly, we must remember that scientific and technological progress needs to be accompanied by ethical reflection and political actions to guide its effects and serve our ideals.

In a few years, the internet will become ubiquitous, invisible, and no longer perceived as a technology that affects our lives, but rather a dimension of our own reality, in which we and objects will be immediately and permanently inserted, without us needing to connect.

Combined with virtual reality technologies, the internet and social networks will keep us interconnected not only through words and images, but also through our senses[2] – for example through the sharing of tactile or olfactory experiences, or experiences of immersion in shared virtual environments.[3]

Growing parts of everyday life will take place in this virtual space. As a result, we can imagine that access to this sphere of existence will join the list of universal rights. In this process, populations that remain excluded from the digital revolution will find it hard to avoid economic and social marginalization.

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Among the digitally included, new patterns of personal relationships are already emerging on the horizon. The psychological and social experience of distance and closeness is ceasing to be anchored exclusively in physical space. The geographical factor is tending to play an ever smaller role in the establishment of work relationships, friendship networks, romantic relationships, and political and scientific associations. Nobody will be condemned to marginalization due to being physically distant or psychologically cut off from the majority's standards. In this situation, an extraordinary quantity of information will be more accessible to each individual. On the other hand, secrecy, solitude and silence will need to be conquered.[4]

1 Marc Goodman, "Future Crimes: Everything Is Connected, Everyone Is Vulnerable and What We Can Do About It", New York: Doubleday, 2015. 2 Adrian David Cheok and James Teh Keng Soon, "Haptics and Touch for Novel Internet Multisensory Communication", S.l.: LAP LAMBERT Academic Publishing, 2013. 3 European Commission, Community Research and Development Information Service, "Enabling Audiovisual User Interfaces for Multisensorial Interaction". Available at <http://cordis.europa.eu/project/rcn/188128_en.html>. 4 John Fredette et al., "The Promise and Peril of Hyperconnectivity for Organizations and Societies", in "The Global Information Technology Report 2012: Living in a Hyperconnected World", World Economic Forum, 2012. Available at <http://reports. weforum.org/global-information-technology-2012/>.

Together with the internet, the exponential advance of communication technologies and computing will expand spaces for the exercise of power by individuals. Ever greater access to information of all kinds will mitigate differences between experts and lay people. The progressive cheapening of digital technologies and the universalization of the internet look set to enable leaps forward in the diffusion of knowledge to all, resulting in greater power to influence among individuals and organized groups.[5] Local acts will have ever more scope to produce global effects. A single individual, wherever they may be, may be seen and heard by millions of people across the planet. The exercise of individual autonomy will be able to expand. Linguistic barriers will be progressively more readily surmounted through the development of ever more effective instant translation tools.[6] Thus, as well as being fantastic instruments for the universal diffusion of knowledge, technologies may also serve to promote tolerance and equality on a global scale, and consequently greater tolerance between different cultures.

The accelerated expansion of biotechnologies is leaving behind the natural limits of the human condition [...]; the concept and experience of paternity, maternity, kinship and affiliation will become significantly more complex and uncertain, requiring constant cultural redefinitions.

On the other hand, a reduction in privacy and control over individuals are tending to expand exponentially. Information about personal correspondence, financial transactions, medical records, aesthetic, political and moral preferences, lifestyles, contact networks, geographical movements – nearly everything will be recorded by surveillance and monitoring systems, by the state, by medicine and by corporations. The issues that should occupy a crucial place on the political agenda to come will certainly include the tension between the pursuit of security and the preservation of freedom, and the struggle for control of information about individuals.

The accelerated expansion of biotechnologies is leaving behind the natural limits of the human condition.[7] Given the multiple varieties of parents' biological contributions and the emergence of new forms of marital and family partnerships, the concept and experience of paternity, maternity, kinship and affiliation will become significantly more complex and uncertain, requiring constant cultural redefinitions.

With the expansion of the possibilities for intervention regarding our anatomy and physiology, the traditional polarization between masculine and feminine will yield more space in the social imagination to spectral visions of sexuality: a pluralistic range of body configurations and gender identities will become ever more accessible and legitimate.

Through bionics, nanotechnology, genetic bioengineering and brain-machine interfaces, other classic polarizations – between natural and artificial, between biological and cultural – will experience a progressive reduction in their relevance. Biological forms, including human ones, will be ever more biotechnologically shaped in line with human choices and decisions – moral, esthetic, political and commercial. We will produce interfaces between organisms and technological devices that are increasingly complex and friendly, and this will greatly expand our cognitive, sensory and communication capacities, as well as the way we perceive our body and constitute ourselves as social subjects, as already predicted some years ago.[8]

5 Lauren Rhue and Arun Sundararajan, "Digital Access, Political Networks and the Diffusion of Democracy", Social Networks, vol. 36, January 2014. 6 Amy Neustein and Judith A. Markowitz (orgs.), "Mobile Speech and Advanced Natural Language Solutions", New York: Springer, 2013; Douglas Jones et al., "Machine Translation for Government Applications", Lincoln Laboratory Journal (MIT), vol. 18, no. 1, 2009. 7 Francis Fukuyama, "Nosso futuro pós-humano", Rio de Janeiro: Rocco, 2003. 8 Donna J. Haraway, "Simians, Cyborgs and Women. The Reinvention of Nature", New York: Routledge, Chapman and Hall Inc., 1991.

The possibility of overcoming natural limits and impositions through practices to enhance various aspects of individuals' biological and psychological life (memory, moods, cognition, sleep, appetite and sex) has been winning over the social imagination.[9] We no longer discuss *if,* but *how* we will make use of technologies to regulate our psychic and social life and improve our bodily and subjective performance.

New hybrid forms of life, simultaneously natural and artificial, will appear. The technological control and regulation of the biological, psychological and social conditions of life will generate countless ethical and political challenges. The boundaries between normality, mere difference, abnormality and pathology, in the fields of biological, psychological and social functioning, will be the subject of intense cultural and scientific disputes.[10] Malaise, a trait inherent to the human condition, may manifest itself in new ways: new forms of suffering, new symptoms, related to the new ideals and the new demands for wellbeing arising in this future situation.

The acceleration of the globalization process will increase interaction between different populations and societies, whether through trade, the circulation of information or migratory movements. This process may enable greater understanding and welcoming of the diversity of human cultures, promoting the expansion of tolerance and the preservation of traditions previously threatened by isolation. On the other hand, it is likely to lead to pressures toward a cultural homogeneity whose development may result in the aggravation of inter-ethnic, cultural and religious conflicts.[11]

We can only speculate as to what situations the future holds for us. The combination of political transformations, cultural movements, scientific discoveries and technological advances will certainly profoundly modify our way of living, but the world that will result from this combination has yet to be defined. Will it be more equitable and inclusive or more unfair and exclusionary? Will we manage to create a more tolerant and shared world, or will we see inequality and violence persist in new ways?

We cannot say for sure what we will be like tomorrow. However, we can and must say clearly what we want to be like tomorrow, because this is the way we will engage in constructing what is to come. The best way of dealing with the future is to realize that we are starting to invent it through the intentions and gestures we are producing in the world today. ●

[9] Steven Hyman, "Cognitive Enhancement: Promises and Perils", Neuron no. 69, February 24, 2011. [10] Nicolas Rose, "The Politics of Life Itself: Biomedicine, Power, and Subjectivity in the TwentyFirstCentury", Princeton: Princeton University Press, 2007. [11] Amartya Sen, "How to Judge Globalism: Global Links Have Spread Knowledge and Raised Average Living Standards. But the Present Version of Globalism Needlessly Harms the World's Poorest", The American Prospect, vol. 13, January 1, 2002; Amy Chua, "World on Fire: How Exporting Free-Market Democracy Breeds Ethnic Hatred & Global Instability", New York: Anchor Books, 2004.

WHERE ARE **ENERGY TECHNOLOGY PATHS** TAKING US?

BY NEILTON FIDELIS, LUIZ PINGUELLI ROSA AND MARCIO GIANNINI PEREIRA

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Imagine the world with its current population of 7.3 billion people, but without the diversity of energy sources we now have. If we still lived in the era of work done only using our own muscles and heat produced from burning biomass, there would certainly not be enough food and firewood for so many people; our life expectancy would be much shorter (the population would probably not be as large as it now is); and we would be very far from enjoying the comfort and productivity that technology offers us.

The whole human development process has a close relationship with the evolution of our mastery and use of energy sources available in nature, and our relationship with these sources is strongly connected to our structures for the production and consumption of goods and services. Developed over time, our different technologies for converting energy have conditioned various forms of use, with different yields, which in turn have created multiple impacts in socioeconomic and environmental spheres.

We ought to ask ourselves how we will proceed from now on. What paths will we choose? What will our technological options be? Driven by what type of energy? Although some of the world's population is investing in more efficient conversion technologies (that expand the use of energy with lower consumption of natural resources and lesser environment impacts), the use of techniques dating back to before the steam engine is still significant on the planet. Thus, despite the technological advances recently achieved, and that are still to come, in many regions the energy future remains linked to yesterday's choices.

To understand this history, from the start we need to remember that, at any time or place, the most complex energy conversion system that humans use resides in our own body. Through digestion, we process converted chemical energy, present in food, into heat and power in our muscles and brain. When transferring necessary work production beyond its body, the human being has two basic ways of converting energy: organic (the use of animal labor to produce mechanical energy, firewood, etc.) and inorganic (waterwheels, windmills, electric machines and internal combustion engines, among other things).

The human being has evolved by exchanging organic converters for inorganic ones. Human and animal traction in the production of goods gave way to mechanized industry, driven firstly by steam and then electricity. In our homes, the use of natural biomass to cook and generate heat has been progressively replaced by stoves, heaters and other domestic appliances, the result of technical and scientific advances that have enabled the use of previously inaccessible energy sources. We have enormously expanded our use of coal, natural gas, petroleum, electricity and nuclear power. Accordingly, each energy source has filled its own distinctive niche, expanding the use and harnessing of energy resources.

In this process, we see that the evolution of humanity took place through mechanization and the replacement of the rural labor force, whose effect was the migration of a large share of agricultural workers to the services sector and the expansion not only of trade, but also cultural goods. These changes have generated enormous benefits for the population, including the reduction and replacement of tiring work, improvements to health and education, and greater security, longevity and income. Furthermore, with the increase in the controlled energy rate, advances have spread beyond the domestic, agricultural and industrial areas, reaching shipping, railroads, and individual and public transport, benefiting new sectors of production based on mechanical and thermal energy.

As can be seen in the following timeline, energy consumption started to increase at an accelerated rate at the end of the 19th century, and grew even more intensely as of the second half of the 20th century.

CHANGE IN GLOBAL ENERGY CONSUMPTION OVER TIME[1]

1700

WORLD CONSUMPTION PREDOMINANTLY RENEWABLE. (FIREWOOD AND BYPRODUCTS)

1800

CONSUMPTION GREW **25%** DURING THIS CENTURY.

1850

IN HALF A CENTURY (1800-1850), WORLD CONSUMPTION GREW **47%.**

1900

BETWEEN 1850 AND 1900, WORLD CONSUMPTION NEARLY DOUBLED. AS FIREWOOD USE DECLINED, COAL BECAME THE LARGEST COMMERCIAL SOURCE. OIL, NATURAL GAS AND ELECTRICITY JOINED THE GROUP OF COMMERCIAL SOURCES. (ALTHOUGH TOGETHER THEY ACCOUNTED FOR JUST 2%)

1950

FROM 1900 TO 1950, GLOBAL ENERGY CONSUMPTION GREW ALMOST TWO AND A HALF TIMES. OIL **24%** | NATURAL GAS **8%**

1970

BETWEEN 1950 AND 1970, WORLD CONSUMPTION OF OIL, GAS AND ELECTRICITY PRACTICALLY TRIPLED. THE OIL CRISIS SPURRED RESEARCH INTO NEW ENERGY SOURCES.

1990

FROM 1970 TO 1990, GROWTH IN CONSUMPTION WAS RESTRICTED TO SLIGHTLY UNDER **35%.** ACCIDENTS AT NUCLEAR POWER PLANTS. DEMAND AND SUPPLY ACTIONS DUE TO OIL CRISIS.

2000

AS THE CENTURY ENDED, FOSSIL FUELS MADE UP **80%** OF TOTAL ENERGY CONSUMPTION. CONFLICTS (SCARCITY AND RESTRICTIONS TO ACCESS SOURCES).

1 Jean-Marie Martin, "A economia mundial da energia", São Paulo: Unesp, 1992.

In a first evolutionary phase, coal became the main fuel for steam engines, rapidly expanding its frontier of use to a wide range of industries. It soon became the energy symbol of the Industrial Revolution. From then on, the generalized mass use of fossil fuels by humanity constituted a new milestone in the harnessing of natural energy accumulation and concentration processes.

As we know, fossil fuels originate in solar energy accumulated in plants and/or animals subjected to a series of concentration and compaction processes lasting millions of years. There is therefore no possibility for replenishment on the economic timescale demanded by society. Thus, when the use of coal expanded and led to the use of petroleum and natural gas, humanity entered the era of consumption of natural non-renewable energy stocks.

In the initial stage of this era, petroleum was only used in lighting and heat generation, through the use of kerosene. Many changes took place as new technologies were mastered, oil came to be used to directly generate mechanical energy, and it very rapidly became the main energy source for transport.

When it came to gas natural, the evolution was slower. At first it was considered an obstacle to oil production. Discoveries of huge reserves and, above all, the continuous growth of energy needs and the multiplication of energy uses, were decisive for the natural gas industry's development. Once the barriers imposed by transport costs had been overcome, natural gas became a major fuel.

A second evolutionary phase may be presented in line with the development of a series of technologies that arose in the late 19th and early 20th centuries, which facilitated the spread of electricity use. At the same time, the invention of the alternating current electric generator and electric induction transformers permitted the harnessing of hydraulic energy to be once more included in planning of energy market expansion. Power transmission networks also played an important role in this revival, by enabling the long-distance transportation of hydraulic energy available in reservoirs.

All these discoveries permitted the simultaneous use of multiple energy sources (firewood, coal, oil and hydraulic) in a very flexible way, with higher yields and better quality. This diversity of available energy sources, combined with the accumulation of new technologies, consequently allowed the development of the complex energy system we have today.

Alongside this, mastery of the controlled nuclear fission process made possible the technological transformation of matter into energy. As a result, it seemed that a third phase of energy use had started, given that, as well as having lower costs, this energy source was considered to be unlimited. However, although nuclear energy now accounts for 9.7% of the supply of primary energy on the planet, through installed and functioning systems, there is recurring debate about its viability, as it has been shown to suffer from financial and environmental problems, most notably risks that threaten the population's safety.

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Another important and more recent development is the large-scale exploration of shale gas – natural gas found inside a type of porous rock known as shale. To remove the gas from this rock, the hydraulic fracturing (or "fracking") process is used, which involves injecting water, sand and chemical products. There is great potential for contaminating the population's water supplies, and some people associate this process with the occurrence of earth tremors. Despite the risks, shale gas production has increased rapidly since the year 2000, especially in the United States, where it is expected to make up 50% of total American natural gas in the mid-2030s.

The current global context is therefore marked by extreme dependence on the production and use of fossil energy and ventures linked to the energy chain that impose high impacts on the natural environment, feeding growing distrust among consumers regarding the use of non-renewable energy sources. This has led industrial society to rediscover energy flows based on renewable natural resources and seek processes more in harmony with human life and ecosystems' carrying capacity. Such flows, associated with new developments in the realms of technology and the organization of production, may enable an increase in energy supply while lessening global dependence on fossil and nuclear fuels.

Among new renewable technologies, technological advances at an international level have been obtained in thermal solar energy, photovoltaic solar energy, bioenergy, wind power and use of solid waste to generate electricity.

Industrial society is led to rediscover energy flows based on renewable natural resources and seek processes more in harmony with human life and ecosystems' carrying capacity.

The development of alternative energy production techniques based on renewable resources will make it possible to establish multiple, flexible energy systems, which use the diversity of available energy sources and technologies in an integral, coordinated and decentralized manner, and without neglecting energy efficiency actions. Accordingly, if used within certain parameters, new energy production may help to minimize the environmental impacts arising from the functioning of the global energy market, aligning itself with the demands of a society concerned about sustainability.

Finally, one should pay special attention to recent debate about the recording and forecasting of increases in the planet's average temperature arising from rising concentrations of greenhouse gases, whose main source is the use of fossil fuels. Many scientists tend to agree with the evidence for close links between energy production and usage and so-called global warming.[2]

Among other strategies, renewable energy sources offer the planet the opportunity to reduce carbon emissions and resume the trajectory of inclusive economic development, aligned with environmental balance, which used to be part of humanity's civilization process, as it was based on renewable energy generation. ●

2 The Intergovernmental Panel on Climate Change (IPCC), "Fourth Assessment Report: Synthesis Report", Cambridge, United Kingdom and New York: Cambridge University Press, 2007.

OCEANS, THE NEW HUMAN FRONTIER

BY DAVID ZEE

With a population of more than 7 billion people, Earth already presents worrying signs of overexploitation of its natural resources, which are now considered on the verge of exhaustion. Humanity is looking for new sources of resources and it can "stretch" a little more its maintenance on the planet by using technology and creativity for its benefit, and unfortunately also by taking advantage of the social inequality factor.

In this context, given the limits of natural resources, the future imposes the imperative need for new options for sources of resources. On this horizon, the seas are emerging as a source for human maintenance, as they are much more available and reachable than other planets, which need to be explored.

To get an idea of the extent to which oceans constitute a veritable Universe to be harnessed, one only needs to consider that people have already traveled to the Moon more times than they have visited ocean depths greater than 3,000 meters. More than 80% of the Pacific Ocean's area is deeper than this, and we have reached such places very few times. It is estimated that we have yet to discover more than 750,000 marine species – in other words, three times as many as we know of currently.

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Since we do not yet know the oceans' potential, the maintenance of important environmental services supplied by the sea – such as oxygen production, carbon sequestration, food production, and heat distribution around the planet – depends on how we will interact with them. So far, we are still "in the red", as we have produced significant negative impacts.

The next 50 years seem crucial for humans to learn to take friendlier paths in their relations with the oceans. Humanity must not miss the great chance it has now to develop new technologies and to avoid making the same mistakes in the seas that it has committed on the continents. The future use of marine resources with social justice therefore depends on the human capacity to know how to respect their limits of use and cycling of natural elements.[1]

It is already possible to note many changes under way in the oceans: rising sea levels and water temperatures, acidification and pollution of coastal waters. These gradual transformations may not affect us at first, but we should take into account that sudden changes may arise from them. The increased frequency and intensity of storm surges, cyclones, intense rain, violent waves and dead zones in coastal environments demonstrates the ocean's potential aggressiveness, hence our concern regarding its degradation. Accordingly, the coming decades may be seen as a decisive period for the rectification of the environmental liability we have accumulated in the last century (including global warming, overfishing, and the gradual and growing buildup of discharged pollutants, among many other elements).

A better understanding of the oceans' natural cycles would be fundamental to promote a change in attitude regarding our relationship with the sea. In addition to losses – which almost always happen – these one-off and extreme phenomena may affect people's safety and their future relationship with the ocean. By making more research efforts, for example, it would be possible to act in this direction, correcting the mistakes of the past and materializing the implementation of new technologies.

One of the first steps toward a change in attitude would be for us to perceive which ocean reactions are evidence of damage and therefore deserving of more attention. One important observation – posing a growing threat of collapse to coastal buildings, ports and even offshore oil platforms – is the fact that our coastline is being significantly altered, with silting or erosion processes observed in many places. The risk of coastal plain flooding, caused by sudden and one-off fluctuations in the sea level due to violent waves and storm surges, is now also a reality.

To propose a new attitude, technical construction and safety standards need to be updated in accordance with the new climatic and oceanographic conditions that are forming. In the medium term, we should also pay attention to the aggressiveness of sea spray, which is causing coastal buildings to deteriorate more quickly.

1 Social justice is understood here to mean the human capacity to develop multiple and concurrent uses of the benefits arising from fishing, the extraction of mineral resources, shipping, sport, food sources, leisure, and the cycling of organic matter, among other things, for the highest possible number of social players present in the marine realm.

Let us look, for example, at urban beaches, which are environments made fragile by human occupation as well as climatic and oceanographic fluctuations. The coastal areas of Rio de Janeiro have experienced a gradual increase in the impacts of significant violent waves.[2] Over the course of 21 years (from 1991 to 2011), we have seen a substantial rise in the average annual number of periods of violent waves in three-year periods. Likewise, we have recorded an increase in the number of days with significant violent waves, indicating growing pressure on these beaches.

In terms of diversity of impacts, we have also perceived saturation over the years, with stabilization at the maximum rate in recent years (from 2006 to 2011). Due to the observed impacts, we recommend preventive procedures to prevent the loss of beach resilience, such as the use of structures to protect against violent waves. Ecological restoration, involving beach nourishment and/or regeneration of vegetation, is one of the recommended strategies.

In Brazil, areas of the coast made fragile by dense human settlement in the South (Santa Catarina), Southeast (Rio de Janeiro) and Northeast (Pernambuco) will suffer significant impacts.[3] Such coastal areas must therefore be adapted to resist these new climatic and oceanographic conditions. The main impacts related to coastal erosion are as follows: reduction in beach width; retreat of coastline; disappearance of post-beach zone; loss of natural habitats, such as beaches, dunes, mangroves and restinga (sandy coastal vegetation); and increased frequency and magnitude of coastal flooding caused by violent waves or very high tide events.[4]

Beaches are mainly used for recreation and coastal protection.[5] In the latter case, it is necessary to establish minimum beach widths to promote greater resistance to the erosive action of waves and prevent them from getting close to urban infrastructure (sidewalks, lifeguard posts, kiosks and coastal avenues). Recommended preventive (anticipatory) measures include artificial beach nourishment and the restoration of sandy vegetation. Macumba and Arpoador, in Rio de Janeiro, are examples of beaches in Rio de Janeiro that have become squeezed between human occupation and the advance of the sea. Thus, one can perceive the importance of maintaining beaches as an element of coastline adaptation in the face of climate change.

The coastal areas of Rio de Janeiro have experienced a gradual increase in the impacts of significant violent waves. Over the course of 21 years (from 1991 to 2011),we have seen a substantial rise in the average annual number of periods of violent waves in three-year periods. Likewise, we have recorded an increase in the number of days with significant violent waves, indicating growing pressure on urban beaches.

[2] Significant violent waves are extreme oceanographic events that cause some type of disturbance to urban functionality or are worthy of note. [3] David Man Wai Zee, "Elevação do nível do mar e adaptação em grandes cidades costeiras do Brasil", in "Mudanças climáticas e eventos extremos no Brasil", Rio de Janeiro: Fundação Brasileira para o Desenvolvimento Sustentável, 2010, p. 52-71. [4] Celia Regina de Gouveia Souza, "Erosão costeira e os desafios da gestã o costeira no Brasil", Revista de Gestão Costeira Integrada, 2009. [5] Alan P. R. Frampton, "A Review of Amenity Beach Management", Journal of Coastal Research, vol. 26, no. 6, 2010, p. 1112-1122.

One of the main parameters taken into consideration for beaches as a protective element is their width.[6] In the case of urban beaches, such as along Rio de Janeiro's coast, it is fundamental to formulate public land use policies, as well as long-term interventions to maintain these coastal systems.

Another important element is water use and consumption. Human beings currently use the oceans as an area for discharging anthropogenic effluents, extracting petroleum and food sources, and transportation. New uses, such as energy production, mining and pharmaceuticals, are possibilities to be considered. In addition, the salinization of groundwater in coastal zones – an occurrence that may arise from climate imbalance – would impede the harnessing of underground springs, worsening the shortage of drinking water.

The projected oceanographic scenario challenges humanity to invest financially and politically in cutting-edge research and also the planning and development of strategies to enhance the use of natural resources. To stop viewing the oceans as places to dump waste, it would be interesting to develop their other beneficial uses for them and not only prepare to occupy them, but also research new ways of doing so sustainably.

A good way to increase the resilience of the cities of the future and the natural environment around them would be to develop coastal management strategies aimed at better land use, respecting coastal fragilities and harnessing their potentialities with wisdom. Another fundamental strategy is to monitor oceans' evolution and behavior to better understand the energy exchanges between the planet's different spheres: the hydrosphere (oceans), lithosphere (continent), and atmosphere (air).

We now have some knowledge of the planet's changes arising from human action. It is up to us to seek the necessary means to reverse this degenerative process in the coming decades. To this end, we need to assume a questioning, reflective and purposeful perspective. Transforming all this data into information that is useful and understandable to society, encouraging people's participation and responsibility in the process, is extremely relevant, as it will favor a change in attitude toward nature.

Who knows, perhaps the oceans are giving us the opportunity to do things right, based on the mistakes we have made on the land, and this might be one of the best options for us. Humanity may live on the planet in a sustainable way if we respect nature and consider it as a partner in our journey. After all, it is not about saving the planet; it is we who need to save ourselves from what we have done so far.

6 Alan P. R. Frampton, "A Review of Amenity Beach Management", Journal of Coastal Research, vol. 26, no. 6, 2010, p. 1112-1122.

CHANGE, UNCERTAINTY AND LACK OF KNOWLEDGE: BRAZILIAN BIODIVERSITY IN THE 21ST CENTURY

BY THOMAS LEWINSOHN

Scientists have no crystal balls to foresee the future, but even so they can make predictions or projections. Scientific forecasts about biodiversity may basically be produced in two ways. It is possible to examine the relationship between various factors (including climate and solar radiation) and alterations to diversity in the past, and to project this relationship forward to future conditions of these factors. Alternatively, making assumptions about how certain factors cause modifications to biodiversity, we can construct a model of cause-and-effect relationships, with which we can predict future alterations.

Before considering the future of biological diversity, let us think about climate. The quality of weather forecast services improved considerably during the 20th century. Predictions of up to five days are now quite reliable. On the other hand, projecting climate change in the coming decades is much more uncertain, and scientists are producing different models (or scenarios) to explore possible alternatives, without assuring that any particular one is more "truthful" or reliable than the others.

If there is uncertainty about the future of the planet's climate, it is much greater with regard to even more complex phenomena, such as those concerning biological diversity. Therefore we have to understand the reasons for uncertainty in order to know whether it can be overcome or circumvented.

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The first issue we are faced with is lack of knowledge. Brazil is one of the planet's highest-ranking countries in biodiversity; as a result, our knowledge about how many and which species live here is manifestly incomplete.[1] This ignorance is especially serious with regard to invertebrate animals and microorganisms. However, we do not even know all the Brazilian species of the most studied organisms, such as larger animals (mammals and birds, for example) or trees. The lack of knowledge is even more severe with regard to the geographical distribution of species. For the overwhelming majority of species, we lack complete distribution maps, not least because there are vast areas of Brazil in which no biological studies or surveys have been carried out, especially in the Central and Northern regions.

Few people realize that extinction most strongly affects a silent multitude of small, unobtrusive organisms, which live in restricted environments. The greatest difficulty in evaluating the vulnerability of this practically countless number of species is that they are disappearing before we have even discovered them, much less evaluate their inclusion on lists of endangered species.

Another dimension of Brazilian biodiversity, in which our ignorance is less obvious but perhaps even more serious, is the way species organize themselves in ecosystems. This organization needs to be understood in order to enable us to grasp Brazil's current environmental dilemmas and make critical choices for the future. Without knowing which animals visit and pollinate plants in cultivated fields, for example, we will not be able to understand and predict the future course of the crisis of pollinators, which is already compromising many agricultural crops in Brazil and around the world.[2]

In addition to the problems of lack of knowledge, we are also faced with uncertainties in projecting past trends into the future. We know less about the past of Brazilian biodiversity than its present condition – this applies both to remote time (including major changes over the course of geological eras) and to recent times (in which alterations have been caused by growing human occupation and modification). Obviously, it is hard to project trends into the future based on a little-understood past. Furthermore, all projections presuppose that future effects will be similar to those of the past, and there are good reasons to question whether this will hold for biodiversity.

Predictions produced based on cause-and-effect models depend on identifying the most important factors in a given process and then ascertaining how they act in combination. Thus, for example, in climate change forecasts for the coming decades, it is likely that alterations of rain and drought regimes will affect Brazilian ecosystems more strongly than changes in temperature itself –bearing in mind, however, that temperature and precipitation or humidity do not affect living organisms independently.

Such uncertainties should be included in scientific models, in order for all the plausible options to be evaluated in line with our current knowledge. We should also add confidence intervals to each forecast, rather than presenting supposedly exact projections. These intervals do not indicate that scientists are incompetent. On the contrary, they are the appropriate way to cope with the uncertainty inherent to systems as complex as environmental ones, based on incomplete knowledge.

1 Thomas M. Lewinsohn and Paulo Inácio Prado, "Quantas espécies há no Brasil", Megadiversidade, vol. 1, 2005, p. 36-42. 2 Brazil – MMA, Funbio, "Polinizadores do Brasil" project. Available at <www.polinizadoresdo-brasil.org.br/index.php/en/>. Accessed on March 25, 2015.

Given these considerations about climate issues, how should we approach the future of biodiversity? The official Brazilian list of endangered species contains 464 species of land vertebrates, as well as eight species considered extinct in Brazil.[3] For fish and invertebrates, this list is much more incomplete, because there are many groups for which the risk of extinction cannot even be evaluated, given the lack of specific knowledge. The Brazilian list of plants now includes 2,113 endangered species.[4] Some of these species only survive in very small populations and depend on very particular environmental conditions in sites that are also disappearing. Thus, it seems inevitable that some of the species on these official lists will indeed vanish in the not-too-distant future.

We cannot say that each species has a unique function in its ecosystem. The extinction of a given species of bromeliad or bird, for example, may not have obvious consequences for the functioning of the ecosystems in which they live. In any case, however, it makes the world a poorer place to live in, even for the vast majority of people who live in large cities and have practically no direct contact with well-conserved nature.

The majority of species are not capable of migrating long distances, except if there are stepping stones, and this requires more or less continuous favorable environments. Cultivated fields, vast areas of pastureland and cities increasingly restrict natural ecosystems to small, isolated areas.

Initiatives to reverse imminent extinctions have been successful in some cases. The best known example in Brazil is perhaps that of the golden lion tamarin, which although still endangered, left the "critically endangered" status in 2003, and whose numbers continue to increase.[5] The recovery of a single species requires huge efforts, including human and material resources, which cannot be replicated for every one of the thousands of species listed as threatened. However, few people realize that extinction most strongly affects a silent multitude of small, unobtrusive organisms, which live in restricted environments. The greatest difficulty in evaluating the vulnerability of this practically countless number of species is that they are disappearing before we have even discovered them, much less evaluate their inclusion in lists of endangered species.

In addition to our concerns about the extinction of certain species, we should expect other alterations in Brazilian biodiversity, which one way or another will affect the majority of living organisms. Climate modifications will force species to shift to regions in which the new conditions are more favorable to them. This displacement may involve anything from small distances between adjacent habitats or upwards on mountain slopes, to migrations over longer distances.

However, things are unlikely to take place in a simple, easy way: the majority of species are not capable of migrating over long distances, except if there are stepping stones, and this requires more or less continuous favorable environments. Cultivated fields, vast areas of pastureland and cities increasingly restrict natural ecosystems to small, isolated areas. Moreover, new regions, which become favorable under an altered climate, are likely to be occupied by homes or crops, preventing or hindering their allocation for biodiversity protection and, moreover, requiring an ecological restoration process.

One foreseeable consequence of species displacements induced by climate change, or directly entailed by human activities, is the expansion of some species that are ecologically aggressive or highly favored by environmental disturbances. Besides altering important processes in ecosystems, the establishment of exotic species in new regions makes the world more ecologically uniform, in a process called biotic homogenization.[6]

3 Brazil – MMA, 2014, "Lista nacional oficial de espécies da fauna ameaçadas de extinção." Ordinance 444 of December 17, 2014. Diário Oficial da União, December 18, 2014, section 1: p. 121-126. Version valid until 2014. 4 Brazil – MMA, 2014, "Lista nacional oficial de espécies da flora ameaçadas de extinção." Ordinance 443 of December 17, 2014. Diário Oficial da União, December 18, 2014, section 1: p. 110-121. 5 Associação Mico-Leão Dourado (2015). Available at <www.micoleao.org.br/images/mico_leao_dourado/ficha_bicho_linhad-otempo.jpg>. Accessed on August 15, 2015. 6 Jean Ricardo Simões and Letícia Pavani Pozenato, "Homogeneização biótica: Misturando organismos em um mundo pequeno e globalizado", Estudos de Biologia, Ambiente e Diversidade, no. 34, 2012, p. 239-245. Available at <www2.pucpr.br/reol/index.php/BS?dd1=7336&dd99=view>. Accessed on August 15, 2015

As already mentioned, the disappearance of interesting species impoverishes the world. However, disruption of ecosystem functioning has broader and more serious consequences, as it affects environmental integrity and the quality of human life itself in many ways. The functioning of ecosystems and many of the services they provide for human wellbeing largely depends on the enormous variety of small organisms, such as insects, algae and microorganisms, which exist in all natural and modified environments. For this reason, it is necessary to invest in the integrity of biodiversity, not only by preserving ecosystems in more natural conditions in protected areas, but also by paying attention to the diversity and ecological organization of the organisms that live in agricultural and urban landscapes.

One example already cited is the importance of native animal species as pollination agents for crops and orchards. Accordingly, the reduction of bee populations is causing concern, as it is harming an ecosystem service of great agricultural importance, which is difficult and expensive to replace.

An even greater complicating factor involves the propagation and successive effects of changes to ecosystems, which may interfere with different functions and generate consequences in other areas even on very large scales. Thus, we do not yet know the entire effects of deforestation that is accelerating yet again in the southern and southeastern Amazon. In addition to disrupting ecosystems in the region itself, it is increasingly evident that this deforestation, combined with the extensive agricultural occupation of the Cerrado region, has contributed to raising temperatures and reducing rainfall in the Southeast region. Among many other consequences, this is simultaneously harming human health, the production of hydroelectric power, river shipment and agricultural production.

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Finally, one last factor further increases uncertainty regarding the future of Brazilian biodiversity. This one, however, also allows for some cautious optimism. Brazil is one of the few countries to still have a wide range of options as to its environmental future, including its biological diversity. This is due to a unique combination of extensive spaces, enormous native biodiversity and a still fairly sparse human population in much of its territory (although it is critically dense in continuously expanding urban areas, especially in the Atlantic Forest and Cerrado regions).

Everything depends on the government and citizens realizing that quality of life, well-being, sustainable production and a solid economy are ultimately inseparable from the integrity and proper functioning of ecosystems. Life will be more secure, healthier and buffered from extreme conditions in landscapes that reconcile agricultural production and human habitation with the preservation of ecosystems. We can only gain by enabling the benefits of preservation to encompass all human requirements and activities.

However, the time to take decisions is fast running out – and, given the uncertainties involved, we should not count on advance notice of the moment when our opportunity for choice expires. ●

THE SHAPE OF THE FUTURE

BY PAULO VAZ

Throughout the 19th century and for most of the 20th century, intense social curiosity about the future was addressed by philosophers and social scientists. It was believed that they were capable of anticipating the future of society based on present occurrences. As their predictions were predominantly positive, it was also thought that philosophers and social scientists could tell modern individuals what they ought to do to construct the "good society." Physicists, chemists and biologists, in turn, said nothing about the future; instead, they were concerned with formulating the laws of nature, of much greater permanence than the beliefs and values of human societies.

In the last three decades, there has been a change in the institutional origin of those who our society has appointed as capable of predicting what will happen to us. The conjunction between, on the one hand, the immense technological progress promoted and promised by computing, genetic engineering and neurology and, on the other hand, the crisis of hope in structural transformations, in the way our society orders its production and consumption practices, has meant that we rarely see philosophers and social scientists venture any prognosis about our future.

The formulation of the laws of nature by modern science has allowed human beings to use a variety of natural processes. Many discoveries have contributed to this: the constitution of atoms and the subsequent appearance of nuclear energy; genetic code, orientating the synthesis of proteins; and the appearance of drugs that alter cognition and feelings, among others. Thus, what makes us think now about the future is no longer violent social transformation, caused by political forces, but the immense power of human action triggered by technical objects associated with our knowledge and control of natural processes.

Although there has been a change in the institutional origin of those who are authorized to speak about the future, the human sciences ought to formulate some essential questions about the catastrophic forecasts that have been made by the scientists of nature. How are these future predictions made nowadays? To what extent does this method underestimate the role of ideas and social structure in the effective formation of the future? And why does the predominant form of conceiving the future limit the possibilities of action in the present, in the pursuit of a desired future?

By focusing social debate on the anticipation of a catastrophic future and the means still available to avoid it, rather than inviting us to think about what would be possible and desirable, many scientists restrict discussion to the need to maintain the present, instead of examining the possibility of changing it. We consequently tend to provoke the desire to retain the present and to link our wishes to the immediate, leaving little room for discussion about the future that we can and want to build.

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The predominant form of this anticipation basically consists of a simulation operation. It presupposes, first of all, the identification of technological fields with dynamism to transform the present.[1] From there, it measures the rate at which scientific knowledge and its technological applications have been advancing, and then extrapolates the overcoming of current limits and even the human condition.

Based on certainty regarding the continuity and development of scientific research, academics view our limitations as a mere technical obstacle. Thus, their logic is as follows: by cloning a mammal, for example, this indicates the approach of human cloning; likewise, given the continuous increase in computer processing capacity, it is suggested that some years from now, machines will be more intelligent than people. The correlation between a mental state and an arrangement of neurons also serves to affirm that, in future, thanks to the advancement of research, we will be capable of chemically altering our mental states with precision.

This type of simulation exercise underestimates society itself and the values that characterize contemporary Western cultures. Cultural values cannot be treated as "mere obstacles", given that they define not only which technical objects[2] will be accepted, but also, and more profoundly, the decisions about what will be researched. Put another way: many products are being researched, but which ones will be accepted, given society's values? And which ones will be researched, if research is increasingly orientated by the market?

Recognizing the importance of this aspect, we may highlight five values present since early on in Western cultures that still guide social discussion about the legitimacy of the use of technical objects. As we will see, decisions about the adoption of technologies are relatively decentralized. According to market logic, technical objects are also goods to be consumed.

We tend to provoke the desire to retain the present and to link our wishes to the immediate, leaving little room for discussion about the future that we can and want to build.

The first value consists of the separation between healthy and unhealthy. Disease is seen as a departure from normality and the natural. So, in a nutshell, it is this departure that requires and authorizes artificial intervention to reestablish a natural state.[3] If the legitimacy of a technological intervention depends on the preexistence of an abnormality, we may, with some irony, note that a society that uses technical objects ever more – and medications are a technical object – will also be one that multiplies the number of diseases and sick people who need intervention to reestablish their wellbeing.

The second value is a very archaic principle, which probably dates back to before the emergence of Western culture, and consists of the belief that individual effort

is needed to have pleasure, or that a benefit is only legitimate if there is a cost. While abnormality authorizes an intervention, the principle of "necessary" effort or suffering concerns the use of objects that "improperly" provide some kind of wellbeing. This value is found, for example, in criticism of medications that produce pleasant mental states and the use of narcotics – considered to be artificial paradises that provide pleasure without effort. However, concern for this issue is longstanding, and Plato's Gorgias dialogue[4] already placed it in a very precise initial formulation: in one passage, the philosopher distinguishes between a beauty achieved through gymnastics and another obtained through cosmetics; and also proposes that a punishment would purify a soul that has committed a crime. Thus, effort to achieve an objective or punishment to redeem an immorality is like suffering that, if inflicted for "good" reasons, becomes a condition for a benefit.

1 As mentioned previously, the most dynamic fields are information and communication technologies, genetics and neurology. 2 Broadly defined, technical objects are all products that require intention, knowledge and transformation of nature for their existence. Accordingly, the definition includes everything from the rods chimpanzees use to "fish" for termites and the polished rocks of our ancestors to the technical objects that have marked modern, contemporary societies, such as the printing press, car, aircraft, television, medications, computers and cell phones. 3 Social debate about cosmetic surgery immediately clarifies what is at stake. Typically, a corrective surgery does not generate any contrary reaction, but this does not apply to elective surgeries, such as cosmetic operations. 4 Cf. Plato, "Gorgias", 463c-465e; 477a-478c.

The third value, which also tends to appear in criticisms of the use of technical objects, is deeply culturally embedded and similar to the value that links pleasure to suffering. It is the value of equality applied to the conditions of a competition. In any and all social situation that could be described as a contest evaluating individuals' performance, equality will appear as a value used to question the use of technical objects. (An immediate example of this type of criticism is doping in sport.) If we observe criticism of the use of medications that improve cognitive performance in schools and universities, and at work, for example, it is possible to even identify the joining of this value of equality with the previous one regarding costless pleasure.

The fourth value is autonomy, and one of its opposites, dependency. For a long time, autonomy was framed in terms of an individual's independence in relation to other human beings, especially the capacity to question their beliefs and commands. Nowadays, however, it is also used to describe the relationship between an individual and technical objects. From this value there arises, for example, concerns about internet access or the use of narcotics and many medications that affect our moods (such as anti-depressive and anxiolytic drugs), as well as gadgets that are becoming practically an integral part of individuals' lives.[5]

The fifth value concerns the dilemma regarding experiences with the potential to affect the human condition, confronting the Christian structure of Western culture with the fact that new technologies have the capacity to directly affect the thoughts and existence of our species. The suspicion that human beings are invading the domain of the sacred or the creator generates a fear that may be observed in two dimensions: the first is of an ethnical kind, and resides in the prohibition for humans to act as god – although new technologies give us power over the future of living beings and even ourselves. We fear losing control of this domain, as could happen if genetic manipulation leads to the creation of organisms that destroy human life, for example.

The second dimension is sometimes characterized as a fourth narcissistic injury[6] caused by the development of modern science: after Copernicus proposed that the Universe does not revolve around Earth, after Darwin showed that the human being is merely an animal, and after Freud conceived that our actions are not dictated by our conscious will, we may now feel anguish due to a possible lack of distinction between living beings and machines, caused by new technologies.

Technology is increasingly leading people to believe that life and thought are mere organized matter and that machines are becoming more and more like living beings. And, in fact, it is increasingly possible to radically conceive of thought as something programmed by natural selection, as it has become more frequent to see that machines are capable of simulating mental processes previously considered to be the prerogative of humans.

When we analyze contemporary conceptions about the origin and destination of thought, the immediate reference is the appearance of the computer and DNA. What disturbs us now is our capacity to construct machines that simulate our thought. Although still to only a limited degree, computers can simulate cognitive processes such as memory, problem solving, choice and forecasting – mental capacities that previously led us to believe that our mind was either a metaphysical sphere forever separated from physics, or something without an equivalent in the animal world, as the result of culture. What makes us uneasy is not just that machines seem so human; it is also what genetic engineering, neurology and new theories about the natural selection process show us: how similar we may be to machines.

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[5] Although the first smartphone appeared in 2002, it is common today to hear people say they cannot imagine their lives without these devices. In just over 10 years, this product seems to have gone from the status of accessory to an indispensable object for individuals' sociability. [6] Narcissus is a character in Greek mythology who fell in love with his own image reflected in water. For the relationship between people's knowledge and self-image, what matters in this myth is not one's love for oneself at the expense of commitments to others. What is of interest is indifference toward what exists; the fact that, out of everything there is in the world, Narcissus only sees himself. With regard to knowledge, narcissism therefore means reducing what the world can be to the dimensions of human desire; it means limiting our knowledge by making the world a mere mirror of our desires. Cf. Bruce Mazlich, "The Fourth Discontinuity", New Haven: Yale University Press, 1995.

Discussion about thought therefore inevitably becomes an ethical debate about the limits and legitimacy of the human attribution of thought to non-human entities. The question "What is thinking?" is now inextricably linked to the question "Who thinks?" Introspection or the study of other cultures is not enough; what is at stake is the attribution of thought to non-humans by a human observer. Would it be anthropomorphic of us to refuse to accept the existence of thought in machines or living beings? Or would we be losing the distinctive nature of thought – an understanding or qualitative experience of the world provided by consciousness – if we were to attribute thought to machines? Should we continue to think about non-humans based on the certainty of consciousness itself, which distinguishes us from other living beings, or should we seize the opportunity to wonder about human thought by equating its functioning to that of a computer, thinking that robots lie in our origins, that we are made up of robots, and that, from a certain point of view, we are merely robots that went from "know how to" to "that know"?[7]

Many of the questions and actions that will shape our future include cultural and ethical values, to be found in everyday decisions affected by the interest and happiness of each individual. The legitimacy, necessity and attractiveness of technical objects therefore call for social discourse to articulate beliefs and values, guiding us in our appraisals regarding what we are, can be and should be.

However, despite all our intellectual efforts, we know little about what the future will be like and what genetics, neurology and computing will permit human beings to be and do. There are two reasons for this essential lack of knowledge. One is part of the human condition: there is always a certain amount of uncertainty about the future that is impossible to eradicate. The other reason is about our culture. More and more, our predictions feature catastrophic content, and are therefore made in the hope that they are not materialized. Consequently, instead of reducing our uncertainty, projections may add to it.

Predictions are partial and ephemeral. The shape of the future is much longer lasting, as it is defined not by any content, but by how a particular culture favors a way of knowing the future, this place of irreducible uncertainty, and it stipulates whether its contours respond to utopian desires. Accordingly, we may conclude that the shape of the future is the essential and determining element in the way a culture relates to time.

For around two millennia, from Plato until at least the 17th century, the temporal split that ordered experience in the West was the separation between the ephemeral and the eternal. However, from the end of the 18th century to the mid-20th century, the temporal split that ordered human experience was between the present and the future. Conceived from the concepts of progress, revolution and liberation, this cultural way of relating to time saw the present as something limited, the past as something to be overcome, and the future, if not a place of realization, then at least an opening, a possibility to stop being what we are and to free ourselves.

Today, our way of looking at the future – which emerged in the 1960s and became hegemonic in the late 1980s – also favors the temporal split between present and future. The latter, however, is anticipated as likely to be catastrophic if our current practices continue. Besides not being conceived as limited, our present is seen as something that ought to remain. The utopian orientation abandons the future and anchors itself in the present, now thought of as a place where all individuals can be happy, as a place where suffering, by right, should not exist.

The preservation and idealization of what exists is the other side of the future as a risk. It is our responsibility to include questioning of the present and the need to reflect about the future we want to build, and to reinforce the connection, now weakened, between our desires and the future. ●

7 This distinction was proposed in Gilbert Ryle, "The Concept of Mind", London: Penguin Books, 1963.

EVERYONE'S TOMORROW IN EACH PERSON'S BRAIN

POR SUZANA HERCULANO-HOUZEL

"Living in the past is for museums." This Brazilian expression condemns attachment to the past, the overvaluation of things gone by and the difficulties in moving ahead. But users of this phrase beware: we all live in the past. And this is a good thing. More than just good, our capacity to use our memories to constantly revisit the past is fundamental for our ability to experience the present and forecast the future. It is according to our forecasts for tomorrow, based on yesterday, that we make better decisions today.

This capacity to represent the past, present and future is the work of the human cerebral cortex, with its remarkable number of neurons, unparalleled in nature and organized in a complex architecture that endows us with amazing cognitive abilities which allow us to do much more than react to stimuli. Thanks to the cerebral cortex, not only do we have a past and a future, but we are also able to represent others, their feelings, emotions and intentions, which enables us to live in society and envision a tomorrow shared by all.

However, what is the basis for these abilities? How do they work? In what way do we use them? For what purposes, and with what results? What future can be built from them?

Over time, the most palpable thing to our brain is the present: our empirical experience of the here and now. The present exists thanks to the senses, which keep the brain updated about what is going on in our body and around us, thereby allowing it to constantly build and rebuild a representation of the current reality.

This process occurs simultaneously on various levels. The sense organs, sensitive to energy variations in the body and its environment, process and transmit information about them to the brain. The sensory regions of the brain represent these variations, building veritable maps of the environment and body, which are combined in other regions of the brain to create a single map that guides our movements and behaviors. In this way, our actions are well adjusted to each moment, to the current circumstances, to the present. Other regions of the brain then use these representations of reality to create "representations of representations", which is how we create concepts about something: the chair to which we have turned our back, the face of someone who has just left the room. Because these concepts can be activated in the absence of the external object, we then have the basis for abstract thinking and also for evoking past and future.

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The representations of the outside world that we build in the brain are, however, not perfect, given that they are necessarily limited by our own senses and influenced by our expectations and previous experiences. Bees see ultraviolet light, which our eyes ignore. Snakes detect infrared radiation, for which we need night vision goggles. Electromagnetic fields interact with our body, but we do not sense them, as electric fish and birds do. In other words, we only capture part of the sensory information from the outside world. Furthermore, the way we interpret this sensory information depends on our previous experiences and mental state. The same sentence can be interpreted in different ways by different people, depending on their mood and expectations; the same object may be recognized more or less quickly, and with more or fewer details, by different people, depending on their level of familiarity toward them.

In addition, our past experiences, present emotional state and future objectives distort the real world, to which we never have true access. Our "reality" is in fact a private, personalized version of the real world, built by our brain as it represents the sensory environment. Accordingly, even living in the same world, different people share different realities and presents.

At first sight, the fact that our sensory system is limited and prone to external influence may seem a disadvantage, but it isn't. Detecting stimuli in the environment and responding to them objectively is such a simple thing that even bacteria and amoebas can do it, and with the single cell that they are. But this is not the life that we lead. Our actions are internally directed and not only responsive. Individuals who merely detected stimuli and responded to them, even if in a coordinated and controlled way, would live eternally in the present, incapable of looking back or forward in time. They would not have the least capacity to relive past experiences and much less use these experiences in order to make plans for the future. Even worse, they would spend life running after events, given that the representations that the brain creates from sensations necessarily lag behind reality by at least one-tenth of a second.[1]

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Life is punctuated by a series of experiences and events, some more striking and others less so. It so happens that the very activation of neurons that represent these experiences in the brain modifies the activated neurons and their connections, especially when the represented occurrences are emotionally significant. As a consequence, the brain has a memory of such events, stored in its new, slightly altered pattern of connections and activation. Each event thus has the potential to change the brain. This process of modification according to experience is called learning; its consequence, the evidence that learning has happened, is called memory.

There are various types of memories, however, and with different storage times. Many of them, generated by unimportant events and considered of little use, fade away almost instantly, making room for new memories. Others, however, especially those associated with other important factors in our repertoire and accessed more often, may last a lifetime. Furthermore, memories are reinforced by the very act of remembering, making us increasingly personalized versions of ourselves.[2]

1 Daniel Wegner, "The Illusion of Conscious Will", Cambridge: MIT Press, 2002. 2 Daniel L. Schacter, "Os sete pecados da memória: como a gente esquece e lembra", Rio de Janeiro: Rocco, 2001.

It is thanks to the brain's capacity to learn and form memories that we have a past. However, memory is much more than a database. The accumulation of past records makes us unique individuals, endowed with personality, autobiography and our own values. When we lose these important records of our past, we lose the essence of our individuality. In Alzheimer's disease, for example, the erasure of autobiographic memories undoes one's personal history and thereby dissolves one's individuality. Patients end up without a past of which to live, and without a future to forecast. They are left merely with a meaningless present, in which even relatives, untethered from a cerebral anchor in the past, are no longer familiar.

The capacity to anticipate a tomorrow, or even better, to anticipate different possibilities for tomorrow, gives meaning to the present and is crucial in shaping our decisions. We evoke the past when we react to stimuli in the present; past and present shape our anticipation of future events.

Anticipation is fundamental, because if we were to wait for events to occur before we respond to them, we would often act too late. Soccer goalkeepers know this well. With around half a second to react to a penalty, they need to anticipate the player's kick if they want to catch the ball. Tennis players also anticipate their opponent's serves, positioning themselves in the place where they estimate that ball will go instants before each serve. This "power" of anticipation is not unique to athletes: we anticipate events all the time in our everyday lives, and just like a trained tennis player or goalkeeper, we do this so automatically that we don't realize it. Some call this anticipation intuition; neuroscience calls it forecasting the future based on the past.

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We have a brain that is fully equipped to wish for a better tomorrow and to act to achieve it. This is not enough, however. A goal without a plan is but a wish.

When making more complex decisions, the brain goes beyond automatic anticipation. Events have emotional value, which is taken into account when weighing up alternatives. The hippocampus, which has access to various parts of the cerebral cortex, generates a "memory of the future" based on projections of past memories. Other parts of the brain access these projections and represent them as objectives and goals; others then plot action strategies. In the brain, the future begins in the past.

The chances of an event going badly – such as failing an exam, for example, or ever more serious and constant floods –worry us thanks to the brain's capacity to learn and update probabilities and to forecast the chance of errors, problems and conflicts in advance. This early apprehension is called anxiety: the ability to worry starting today about things that might become a problem tomorrow. The downside of anxiety is the chance we may lose emotional control and become overwhelmed and paralyzed by negative expectations. The good aspect, however, is that by anticipating bad events, we can act now to prevent them from materializing, or at least start preparing in advance and thus be able to deal with them more efficiently when they actually happen.

Positive expectations, however, are highly motivating – including the expectation of solving a problem that has been anticipated. Positive forecasts activate the brain's reward system, responsible for the sensation of pleasure that, associated with an idea, transforms it into a wish. In turn, wishes are the basis for formulating goals. In other words, envisaging good things motivates us to act upon our wishes.[3]

[3] Suzana Herculano-Houzel, "Fique de bem com seu cérebro", Rio de Janeiro: Sextante, 2007.

We thus have a brain that is fully equipped to wish for a better tomorrow and act to achieve it. This is, however, not enough. A goal without a plan is but a wish. Without these three well-aligned elements, we are no more capable or free than amoebas reacting to events. We need wishes in order to have goals; we need goals to guide our behavior; and we need appropriate strategies to act today to work toward our desired goals. To this end, it is also fundamental to find motivations in the near future – in other words, to envision something positive that makes our efforts worthwhile.

There is an extra detail, however: individual goals, plans and actions do not guarantee a better tomorrow for all. Society needs to be in harmony with respect to people's desires and motivations to plan for a future in common.

It is thanks to having a brain that also processes not only our emotional state, but also that of others, that we are able to live in harmony, concerned about one another's future. Our decisions take into account not only the anticipated impacts of our choices on our own immediate and distant futures, but also their anticipated impacts upon other people and their emotions.

We are able to place ourselves in other people's shoes thanks to empathy: the brain's ability to automatically represent and feel other people's emotions, thus taking them into consideration. Observing the expression of emotions on someone else's face is enough for our brain to internally imitate their emotion and thereby identify it.

Projecting how others will emotionally react to our own actions also works, activating the same areas of the cortex that represent our and other people's emotions. With one major difference: while empathy is automatic, putting ourselves systematically in other people's shoes before making a decision is something we can consciously work to make a habit. Thinking of others is something that our brain can always do, but actually doing so is something we can choose – and it enormously facilitates good social relationships.

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And, with a little more effort, we can go even further. Structures located in the temporal lobe of the cerebral cortex allow us to form a representation of someone else's point of view and, based upon this, infer their intentions. Forming a "theory of other people's minds" is extremely important for social judgment (the evaluation of other people's actions as right or wrong) and for life in society in general. It is through our ability to take other people's intentions into consideration that we achieve tolerance, understanding why someone acted or thought in a certain way, and that we can act based on a common goal, believing that we share it with other people.

Living in society is complex – and thankfully so. Different people have different temperaments, preferences, life stories, and moral, political and religious beliefs. Diversity is enriching and creates a multiplicity of possible futures. Acting to promote a harmonious and positive tomorrow for as many people as possible necessarily involves striving now to cultivate good habits of thinking about others, adopting their point of view and understanding their intentions. We neither live alone nor build our tomorrow by ourselves. But we do all have something in common: the ability to use our past to work toward a better future. ●

HOW DO WE WANT TO PROCEED?

Faced with the practically infinite extension of "deep time", which governs the Cosmos and marks the rhythms of life on Earth, with its scale of millions of years, our first shock is our insignificance. Given the changes we have made to the planet in just the last 200 years, we have another shock: our importance. In a period of time corresponding to only a few generations, we have altered the reality of our planet, from the seabed to the atmosphere, to an extent that our ancestors never could have imagined. Some of these changes are perhaps irreversible. Other aspects of reality, however, in the world and in ourselves, may still be determined by the choices we make. Multiple paths open up in the maze of possibilities that unfolds before us. Which doors do we need to open and which ones should we close? The future to be built depends on the choices we make. And the time to choose is always now.

NOW

US

THE HUT OF KNOWLEDGE: **TOMORROW STARTS TODAY**

How do we want to proceed? Understanding how we want to live, with the world and one another.

If our museum has “Tomorrow” in its name and each stage of its journey is associated with an aspect of time (Always, Yesterday, Today...), why should it culminate precisely in “Us”? The meeting between the first person plural and the future is imminent. What good – or bad – things does it portend?

We are all familiar with the concept of a time machine. From H. G. Wells’ novel to science fiction movies, we have become used to observing, fascinated, as characters are launched straight to a future 1,000, 5,000 or 1 million years from now. They are somehow catapulted from the present to an extemporaneous, out-of-time now. In these representations, the “ship” in which we undertake this voyage is generally destined to go along this straight line, to which, at some point, the future has been arbitrarily fixed.

Other less obvious representations explore alternatives such as lateral deviation options. Instead of following a straight line, our hero suddenly appears ahead and – in another surprise – he can make the return journey, going back in time, leaving a now-now for a now-past now. All these visions have features in common, however. In them, time is generally seen as a figure that unfolds in the plane of space. Furthermore, our adventurer is always an individual hero. This should not be of any surprise to us: humanity obviously would not fit into these futuristic vehicles.

Apart from a naive idea, activated by a greater or lesser number of levers and driven by more or less disheveled scientists, what mobilizes our imagination about these fantasies is a fascinating possibility. This possibility was expanded and turned inside out by science as of the 20th century, as we now conceive of time in a very different way. The Theory of Relativity, for example, talks to us about loops in time, in which we march ever forward, do not make any deviations, and yet, paradoxically, arrive back at our starting point.

In a more complex way than the one adopted by a mechanical clock, what is being worked on here is the dimension of tomorrow, a present not yet lived, a purely conjectural present: a time that only exists in the imagination.

Just over two centuries ago, an extraordinary device started to take charge of our lives: the mechanical clock. To some extent, it is also a time machine, as it leads us to experience a certain kind of temporality. It began to tell us, every moment, in which place on the road of time we find ourselves. At a given instant we are at the point that marks midday; later we will be at the point that marks two o'clock – something like 2 km ahead, just as previously we were 2 km behind.

However, a certain quality is lacking from this temporality. A quality we find, for example, in a carved ivory object, discovered by archeologists in the French countryside and produced 30,000 years ago. What first attracts our attention in that artifact is its apparent uselessness. It cannot be used to hit, drill or cut – none of those functions we would deem essential to an inhabitant of the Pleistocene. Nevertheless, regular marks are carefully and laboriously inscribed in its surface. Why was such a deliberate action taken? What is the function of these marks? Scholars finally realized that it was a representation of the Moon's cycles. On the back there are elementary drawings: ripples, the outline of a fish and the shape of a seal. On this extraordinary object, regularities in time – the Moon's cycles and the migrations of schools of fish – are recorded and associated through spatial regularities. In other words, it is an artifact that converts time into space. Through it, the artisan preserves and shares with the community the knowledge accumulated from countless observations of the phases of the Moon, the tides, the season when salmon go up rivers, attracting seals behind them. In a more complex way than the one adopted by a mechanical clock, what is being worked on here is the idea of a present not yet lived, a purely conjectural present: a variety of possible futures, which only exist in the imagination. The dimension of tomorrow.

Many types of "tomorrows" were until recently outside our field of perception, given that our senses can only perceive objects of medium dimensions. Very small or brief things – or, conversely, very vast or long-lasting things – were outside our horizons. We were therefore excluded from sensing both microscopic and super-structural dimensions; the ephemeral or very fast, and the perpetual or infinitely large. Until then, it is as if we were observing the world through a very narrow window, leaving outside our field of vision many of the modalities encompassed by the word "tomorrow." For example, thanks to the resources of science, we now interact with extremely long-lasting objects, which until recently were ignored by us.

We therefore live in a singular moment, unprecedented in all our history. As the French poet and essayist Paul Valéry said in another context – the shock caused by the carnage of the First World War – "the future is not what it used to be." In reality, this phrase makes even more sense for us, the first generation to live with the new objects that have been included within the frontiers of what we consider the world: objects of vast dimensions, like global warming. This is a phenomenon that cannot be grasped by the senses. Nevertheless, our sensors, distributed on satellites, are capable of telling us that a planetary-scale process is under way. The same can be said of the vision of Russian astronaut Yuri Gagarin, who shared with us his unprecedented view of Earth as observed from space.

Armed with this new knowledge, we return our eyes to the past and we realize that long-term events, of geological nature, have had historic consequences, such as the volcanic eruption and resulting tsunami that destroyed the magnificent Cretan civilization, inspiring the myth of Atlantis. Geology acted on history: the excessive has therefore always acted, in the form of the unexpected, the unforeseen, the accidental.

Now, however, we are faced with something very different: it is history that is becoming geology. By detonating the first nuclear bomb and those that followed it until the 1970s, our species produced a deposit of radioactive materials around Earth that is entirely artificial, and it will remain there for many thousands of years. In other words, no natural process would be capable of laying down this deposit. A human gesture, an artifact produced by us, has had a global effect. Therefore, the human being has made geology. Human time, so short, has been capable of achieving these vast durations of nearly cosmic character.

Entities such as these radioactive deposits, global warming or the vision of Earth as an integrated system are objects of great duration, which we will have to live with going forward. This is our time. This is the age of humans, the Anthropocene. We will no longer live like our ancestors, but in a very different world, which we ourselves will construct.

The reflection proposed by our museum is aimed at demonstrating that we are an integral part of the Universe and that Earth is a complex system, whose equilibrium is fundamental for our survival. At this moment we are confronted with a fact indicating a new era: our actions are having an unprecedented impact on Earth. Moreover, we now already perceive various trends in the development of our species and its relationship with the planet, pointing to different possibilities and futures. Faced with this crossroads before us, we will have to make choices.

In the last stage of our journey, the emphasis is not on information, but values. They are associated with the way we want to live: interacting sustainably with the world and with other people. And it is in this space that we find one of the museum's few physical objects, a churinga: an Australian indigenous people's artifact designed to house the soul of a member of the community after their death. The soul remains there until it can reincarnate in a child's body. In this way, it symbolically promotes a connection between past and future generations. It represents the collective spirit, a sense of belonging to a group and its purpose to move on. To us, belonging is no longer restricted to a small village, but it encompasses the whole planet and all of humanity, sealing a commitment to the sustainability of life and peaceful interaction among human beings. The churinga represents the knowledge we acquire and pass on. It is up to us to decide what to do with this knowledge.

Not by chance, this object is placed in a ritualistic space, in an environment that invites contemplation. As the stage for this reflection, we chose an environment inspired by a hut, a home of indigenous people's knowledge, a structure erected in the material language of wood, bringing together the members of a given community. The elders tell the youngsters myths and legends about their people's creation and formation, promoting continuity between past and future. Earth is our village and the world is our community. In this space, we present two concepts: the idea that dawn is breaking somewhere, i.e. in some place, now is tomorrow; and the idea that tomorrow is always the same, and yet always different.

The last moment in our journey through the museum should correspond to the first steps of visitors, who are ready to return to their everyday life. Facing the familiar landscape of Guanabara Bay, they may embrace another vision of our species and their role in constructing a new protagonist of this future, a planetary community, willing to make choices able to change reality. This new subject is US, and our time is now. ●

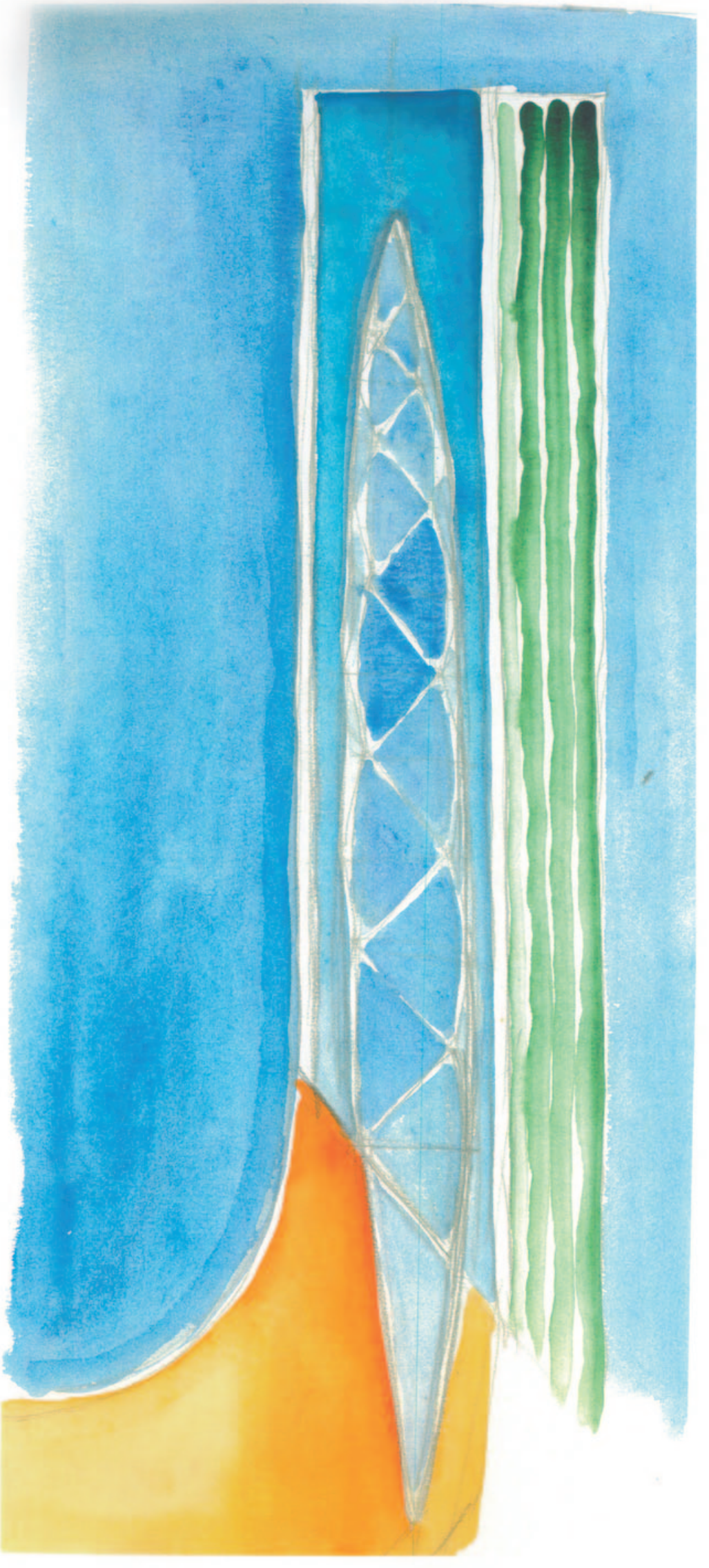
The churinga represents the knowledge we acquire and pass on. It is up to us to decide what to do with this knowledge.

The experience
of going through
the museum’s internal
space should be
like crossing a
single space,
but one that is
transformed at
every stage by the
various forms created
for the exhibition.


QUATRO
OCEANOS


TGGTCTACCC
VIDA ES CODIGO Y COMBINACION
CCTATCAGAAAGTG
LIFE IS CODE AND COMBINATION
TATTTTCATT
VIDA É CÓDIGO E COMBINAÇÃO
CCGCACTTCGAC


CADA
PESSOA É UM
ECOSSISTEMA
UNICO



THE SHAPES OF TIME

For a museum, the goals are ambitious, both in terms of content and also values and ideals. The Museum of Tomorrow's narrative seeks to present the infinite variety of the Universe, go through the bases of life and reveal the moment we are experiencing. Moreover, it intends to inspire reflection and call on people to construct a future based on our choices for the tomorrow we want. What physical space would be able to host a venture like this? And how could we ensure that a message of such complexity would be presented so as to enchant the public? To tackle this challenge, both the architecture and museology involved in the design avoided the usual, well-known trails, preferring to engage in innovative paths. By doing so, Rio's new museum has added to a series of institutions that at the start of the 21st century have promoted across the world a veritable revolution in hitherto-predominant museum design conceptions. The Museum of Tomorrow is a privileged setting for those who want to experience this debate and stay abreast of the latest chapters in this scientific, educational and artistic adventure.

Directing innovative initiatives such as the Museum of the Portuguese Language, the Soccer Museum, the Palace of Frevo and the Rio Art Museum (MAR), the Roberto Marinho Foundation has built up precious experience by making room in the country for a line of museums that seek to establish their relationship with visitors on new terms. Focused on this goal, these projects have sought to harmonize the three pillars underlying the genesis of a museum: its architecture, curatorship and museology.

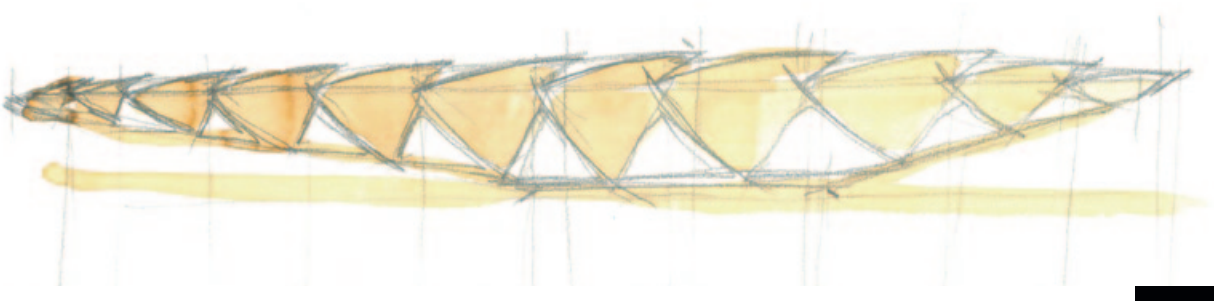
Rio city government's invitation to the Roberto Marinho Foundation to occupy Praça Mauá's pier site with the Museum of Tomorrow represented a distinctive challenge, because unlike with the Museum of the Portuguese Language or the Rio Art Museum (MAR), itself, it did not involve occupying or adapting an existing building, but instead to a certain extent it meant starting from scratch. And this first step was taken by Mayor Eduardo Paes, who suggested inviting the architect Santiago Calatrava to design the structure that would host the new museum.

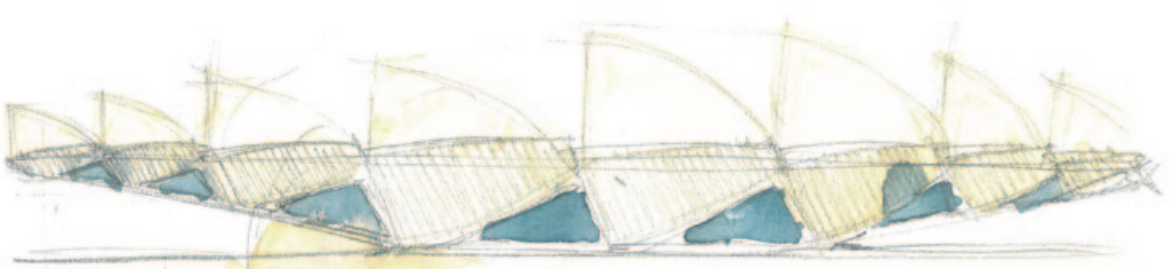
STILL ON PAPER: PART OF THE PROCESS OF CREATING THE ARCHITECTURAL PLANS, THE WATERCOLORS OF SANTIAGO CALATRAVA GIVE LIFE TO THE MUSEUM'S DESIGN.

The negotiations between the Roberto Marinho Foundation and the architect represented a first move to integrate the different aspects that would make up the new museum's profile. Another important moment was the foundation's invitation to New York-based Ralph Appelbaum Associates to produce the museum's exhibition design. Its founder, responsible for seminal projects such as the Holocaust Memorial Museum in Washington D.C. and the renovation of New York's American Museum of Natural History, has over the last two decades promoted a profound transformation in the creation of museums and exhibition design, working on five continents, in countries as different as the United States and Nigeria, Norway and China. Determination to propose that visitors immerse themselves in a given theme, always supported by a narrative, is the common characteristic of all the projects of this award-winning firm, which had already worked with the Roberto Marinho Foundation on the Museum of the Portuguese Language. This same objective would also prevail at the Museum of Tomorrow: to evoke a basic idea through a story, told not just through language, but also sensory experiences to be felt by visitors.

Santiago Calatrava, who was responsible for the architectural aspects of this triangular dialogue, which also involved content and museology, demonstrated sensitivity and respect for the landscape and history of the city when inserting his design in the port area. "When it became clear that we would be intervening in this area, the first thing to take into account was the existing buildings there", said the architect, alluding to the nearby São Bento Monastery, declared a UNESCO World Heritage Site in 2014, and the building formerly occupied by the A Noite newspaper, in Praça Mauá: "We decided to establish a maximum height for the museum, of 15 meters, in order to avoid obstructing the view of these buildings from the sea." The monastery's position in the landscape led the architect to make a reference to Lisbon. "For me, it plays a role similar to that of the Jerônimos Monastery: it was an imposing image seen when arriving by sea. Our museum is low in order to allow this view", he said. The building's height also complies with a ruling by the National Institute of Historic and Artistic Heritage.

Dialogue and harmony with the surrounding buildings – a concern of Calatrava's – did not involve imitation, but contrast. This was the case, he says, in relation to the São Bento Monastery. During an interview, he removed one of his notebooks from his briefcase – he has thousands of such notebooks, all duly filed away by his wife in his office – and he began to sketch with a pencil. With agile movements, he outlined the silhouette of São Bento Hill, thick strokes suggesting a heavy, hulking mass. From the hill, the lines drawn by him raised up the straight and imposing shapes of the monastery.





The architect explained that, with the Museum of Tomorrow, he wanted to make a building "that is projected into the future." Explaining his sketch of the monastery, he commented on the historic building's link with the past: "If we stop to analyze things, we will surely see São Bento Monastery in this way: firstly, the hill, before it had any buildings, would be a great rock. Then the monastery building emerges from that rock, as if it were part of it. In addition, it is also built from stone. We could therefore think of it as belonging to a type of architecture, a mineral architecture."

Consequently, he sees his design for the Museum of Tomorrow as a counterpoint to this characteristic. "Faced with this type of architecture, something leaving the rock, we decided to take a different approach, producing something so light that it looks like it intends to fly. If that architecture is mineral, ours is aerial." Calatrava notes that the museum's roof features a metal structure of a shape that resembles wings – and that these wings move in accordance with the sun's position to capture solar energy.

This fact highlights another aspect of the contrast produced by him. "The first type of architecture – the monastery's – is static and conveys an idea of permanence. Our design, with these mobile elements, seeks to convey the notion of something dynamic, changing, light. All this is important in understanding this contrast." The sum of the qualities described by him practically amounts to a manifesto. "I believe that architecture from this point on will end up following this path, looking for a nature that is perhaps atmospheric, assuming the character of a living organism."

According to Calatrava, the Museum of Tomorrow's design represents a step forward in the evolution of his style. "In a way it reveals an effort to renew my vocabulary. Until then I had been working based on shapes associated with the human figure", he explains, while tracing in his notepad the lines of a woman's body.

We decided to take a different approach, producing something so light that it looks like it intends to fly.

Known for painting dozens, sometimes hundreds, of watercolors before finding the solution to be applied to a new project, the architect saw the possibility of a different path during a visit to the Rio de Janeiro Botanical Garden before he started to design the Museum of Tomorrow, in 2010. Observing some flowers of the bromeliad family, typical of the Atlantic Forest, he became intrigued by the complexity of their shape. This was the first step that would lead him to change the model of the human body for that of a plant. Worked on in a new series of watercolors, his impressions were slowly digested and decanted until transforming into the seed of the Museum of Tomorrow's design. "It influenced me", says the architect. "This here is a clear reference to the world of plants, to organic growth. As with my sculptures, this design transmits a sense of growth. This series of elementary rhythms has something to do with plants."

Calatrava is the first to admit that the impact, in plastic terms, exerted by his design is also sculptural. In Rio for a last visit to the Museum of Tomorrow's construction site before its opening, the architect also expressed enthusiasm for that summer's outdoor exhibition of seven enormous sculptures of his along Park Avenue, New York – large metal structures, some in bright colors. "I express myself more freely in sculptures because they are plastic creations. In architecture, the process is obviously much more challenging. It is a structure that needs to be functional as a museum."

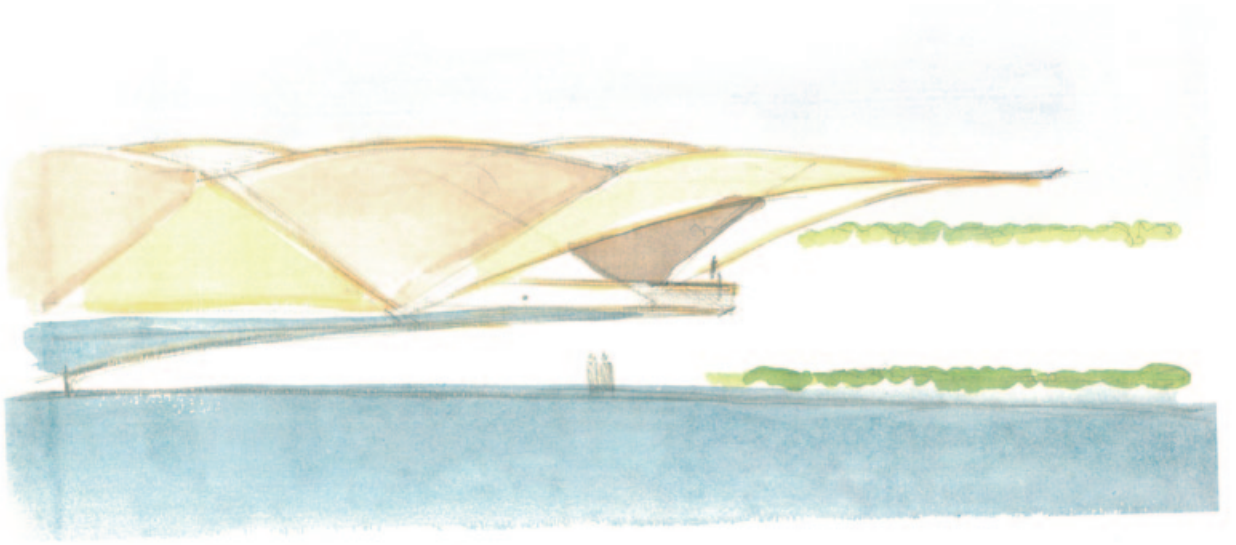
The experience accumulated by the architect in recent years, spanning a portfolio of major projects in countries such as Spain, Belgium, the United States and China, has confirmed his belief in architecture's transformative powers in the cities where it is present. "Great public works are capable of changing cities, creating new spatial points of reference. However, this does not just mean creating iconic buildings", he says.

This new way of conceiving of museums implies the creation of an environment in which numerous resources – from lighting to audiovisual media, from appeals to the senses to indoor architecture – are employed in order to make visitors experience a certain item of content or information.

The fact that museums have played a prominent role in these experiences is significant. Among the many high-impact designs signed by Calatrava are the Milwaukee Art Museum in the United States, and the City of Arts and Sciences in Valencia, Spain, completed in 2009. "It is necessary to understand that these projects should not be seen in isolation, but in the context of their cities. Museums in particular, which have experienced a revival for some years, are not only centers for spreading culture, but also play the role of urban myths – a bit like the great train stations in the European capitals in the 19th century – that are capable of transforming cities."

According to Calatrava, the experience of Valencia – a project on which he worked for around 20 years – is especially illustrative of this point. "I believe we managed to achieve this objective with the Palace of the Arts in Valencia, located in what was one of the most neglected parts of the city, near the port, a post-industrial, obsolete and derelict area. The area has now turned into one of the city's most visible places, where people most want to live. Not only was the urban landscape transformed, but a new benchmark for people and the city was also created. The city's image among visitors and inhabitants themselves has changed a little."

In the case of Rio, the most obvious sign of this transformation, however, is perhaps the disappearance of the "Perimetral" elevated highway from Rio's landscape. "One of my greatest sources of satisfaction was the recognition of the former Perimetral as something obsolete. By removing it, we have managed to restore the relationship between two axes, Avenida Rio Branco and Praça Mauá, with its monument. A genuinely urban connection has been created", he says, pointing to the double row of trees running alongside the museum.

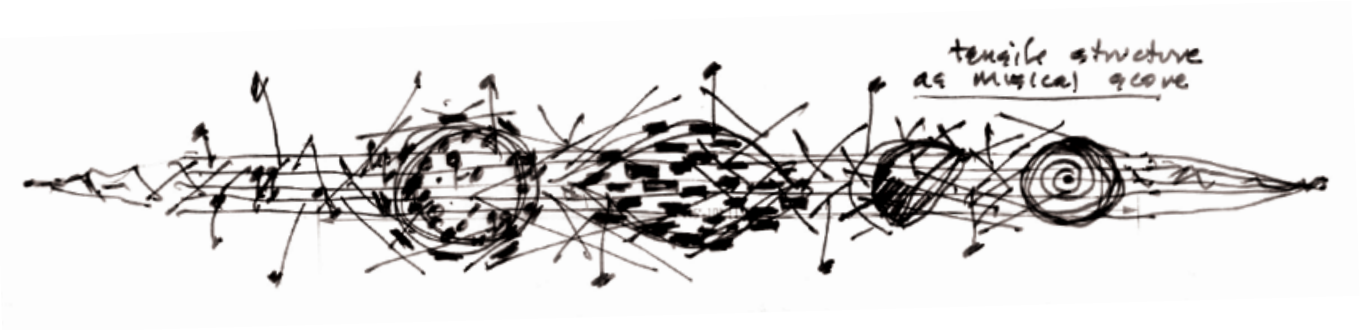


Elevated highways of this kind, a solution very much in vogue in the 1960s and 1970s, are not just a problem in Rio, he notes, mentioning one that dominates the landscape of Bronx, in New York. “There they produce a brutal impact on people arriving in the city. Here in Rio, this issue has been revolved with great elegance. I believe it is a pioneering scheme”, he praises, noting that the lack of anything, a free space, emptiness, also has meaning in an architectural design or urban plan. “As composers say, silence is also a part of music.”

The many technical resources required in the engineering plan were devoted to the construction work, which although complex, hosts a space that is in some way elementary: “The museum has a very archetypal plan. It is almost a cathedral’s nave, open on both sides. I use the image of a cathedral not so much for the atmosphere I wanted to create inside it, but for the nature of a certain type of building that can last 1,000 years, because it follows very elementary parameters, serving and adapting to multiple functions.”

The design and opening of the Museum of Tomorrow put Brazil in line with an emerging trend on the cultural stage across the world. Ralph Appelbaum is the leading spokesperson for the recent transformations international museums have been undergoing. Traditional museums used a formula familiar to many generations of visitors. Imposing staircases, classical columns and a central hall under a large dome received visitors in galleries that displayed collections of objects, generally protected in glass cases. “One wing or gallery did not always relate to the next one, and visitors were no more than observers in them”, says Appelbaum. He argues that “museums ought not to consider themselves as mere open portals, but should think of themselves based on their relationship with their visitors.” Inspired by this vision, he has become known for his efforts to bring to the fore in each museum a basic idea or narrative able to unify the set of experiences and content provided to the public.

In his opinion, this new way of conceiving of museums implies the creation of an environment in which numerous resources – from lighting to audiovisual media, from appeals to the senses to indoor architecture – are employed in order to make visitors experience a certain item of content or information. In them, the public are stimulated not only to think, but also to feel; to resort to both reason and emotion. The results have been encouraging, in a world where it is ever harder to draw rigid boundaries between entertainment and education. The “great ideas” destined to sustain these narratives also transcend the merely aesthetic or pedagogical level. According to Appelbaum, today’s museums “are essentially ethical constructions”.



AS CONCEIVED BY RALPH APPELBAUM, RESPONSIBLE FOR THE MUSEUM'S NARRATIVE, EXHIBITIONS WILL OBEY A RHYTHMIC EVOLUTION, LIKE IN A MUSICAL SCORE.

Appelbaum came up with the idea of establishing a rhythm for the Museum of Tomorrow's narrative, configured like a beating heart or musical score. This basic intention was maintained during the transformations through which the proposal went during the nearly five years of preparations. At the end of the process, there prevailed the museum design concept of occupying the building's nave and unfolding through moments of the same narrative. "In this way we wanted to avoid the logic of a corridor, through which visitors merely advance through exhibition rooms, from one space to another", explains project manager Deca Farroco.

It was up to creative director Andres Clerici – together with a team of curators and museum planners, as well as Vasco Caldeira, of museum exhibition design firm Artifício Arquitetura e Exposições – to tackle the challenge of clearly articulating the museum's central idea and specifically applying these general principles to the content of each moment into which the narrative is divided. Clerici, who has experience in working with what he calls "museums of ideas", explains that, at first, he plays a role similar to that of a psychologist, or even a medium, probing the team of curators and specialists in order to collectively discover the central idea that will guide the museum: "What is the narrative? What story do we want it to tell? We want to convey ideas through stories that engage the public in discussions about certain themes." In the case of the Museum of Tomorrow, his narrative may be summed up in the belief that we have reached a unique and singular moment of human civilization. The Anthropocene is a condition created by us. Nothing will be able to remain as it was before, but the tomorrow to come is being created by us now.

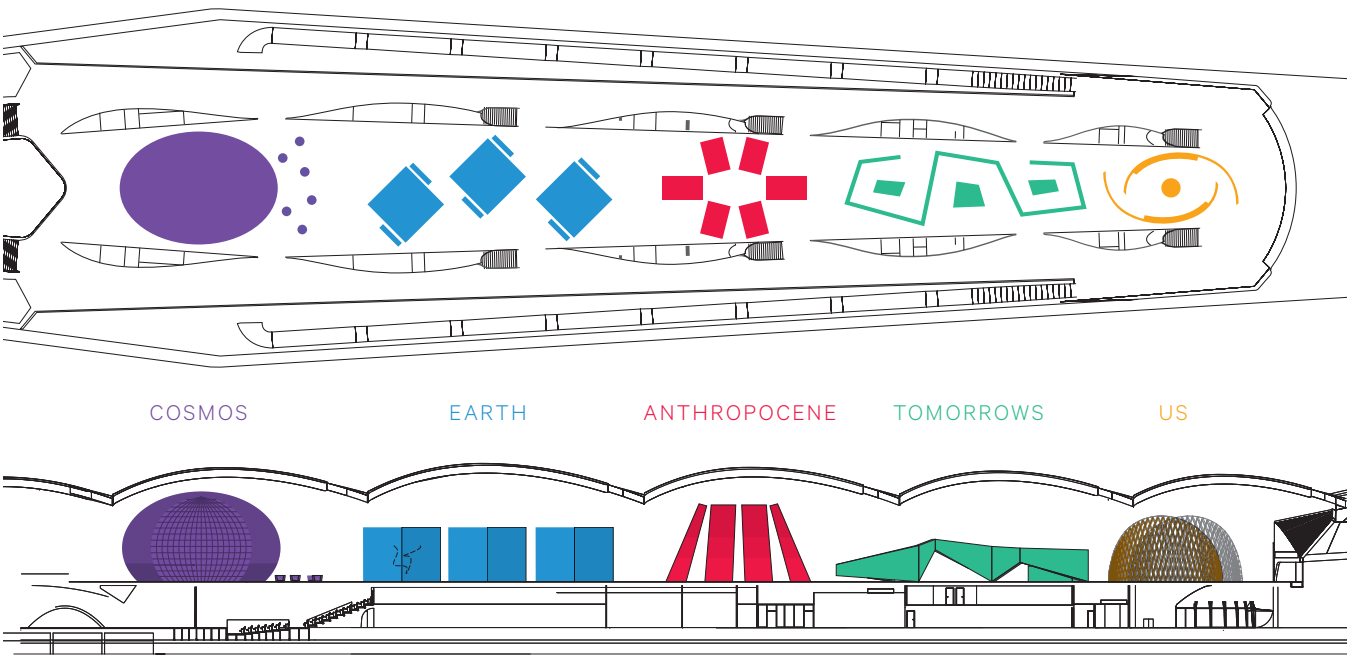
Once the narrative had been defined, it was only left to decide how to tell this story; to find a suitable way to transmit this content. The essential ideas should be conveyed mainly through experiences in a certain physical space, always in a way that engages visitors. In all, around 50 experiences are offered, all linked and distributed within five basic areas, embodying the great questions that humanity has always asked. Where did we come from? Who are we? Where are we? Where are we going? How do we want to proceed?; in other words, what life do we want to construct? The objective is for the public to experience and explore this sequence of questions, all related to different concepts and content, embodying certain elements of time.

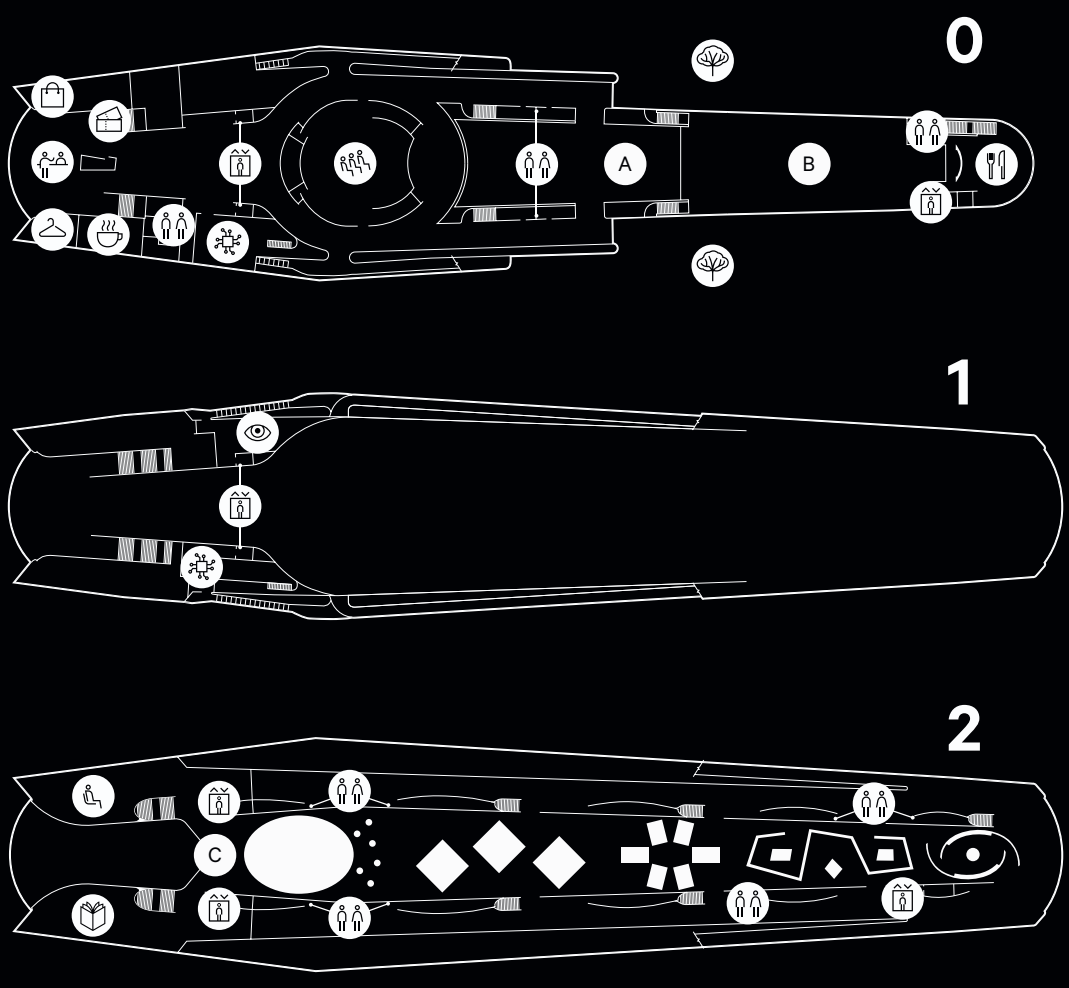
In the view of Andres Clerici, the museum project's biggest risk was falling into the trap of a "futuristic" vision. In the effort to transform content into experiences, the idea was to avoid a vision that, although created today, would look dated in a few years. In the pursuit of solutions that would resist the passage of time, the creative director favored "classic" forms that, due to their elementary nature, would not age.

For example, the first experience of the museum's visitors is focused on the figure of a large black egg, representing the idea of origin and belonging to the Universe. It is a simple and timeless shape that will survive the passing of time well. Accordingly, squares, cubes and other elementary geometrical shapes that will always be recognized were used. In addition to the black egg, which symbolizes our origins, other examples of these shapes – simple and concise yet full of meaning – include three large cubes, each measuring 7 meters across. Called the "Boxes of Knowledge", they feature information about the planet, life and culture. In the moment dedicated to Tomorrow, it was decided – after ruling out other possibilities, including a plaza – to choose an origami object, which presents content in other areas in an integrated way.

Also in relation to the world of shapes, the museum's design has established a sensation of advancing from the solid and closed toward the open and abstract. "The egg present at the start of the visit is a solid shape, while the hut is open; it does not have a roof and it is not closed", explains Clerici. Installed in the last moment of the narrative, the hut provides a space for people to think about their tomorrow. In doing so, the environment stimulates a new notion of belonging: no longer to a city or country, but to the Universe. The hut embodies a timeless form, like totems, which are also present in the exhibition. The important thing, according to the artistic director, is for visitors not to see all this from outside, as if they were watching a movie, but as a part of it. In this way, moments that are in some way theatrical are created.

Theater, involvement, experiences... A vocabulary that expresses the enormous array of resources available to the artists, theorists and technicians who are rethinking today's museums. Avoiding the false dilemma that obliges people to choose between reason and feeling, reflection and emotion, both the exhibition design and architecture of the Museum of Tomorrow seem determined, in equal measure, to haunt us and make us think. ●





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- Tickets
- Information
- Store
- Checkroom
- Café
- Audtorium
- A — Temporary Exhibition
- B — Administration
- Restaurant
- Garden

1

- Observatory of Tomorrow
- Laboratory of Tomorrow's Activities

2

- Meeting Point
- Educational Area
- C — Main Exhibition

- Restroom
- Elevator

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