CNES MAG

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EXPLORING LIFE'S ORIGINS

THE ULTIMATE QUEST

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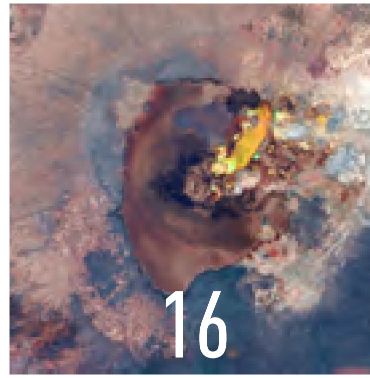
INSIDE



PARTNERS

In this issue: p. 10-11-18-20-21-22-23-29-31-34 NASA; p. 6-11-18-21-25-26-29-34 ESA; p. 10 LATMOS atmospheres, environments and space observations laboratory and LISA inter-university laboratory for the study of atmospheric systems; p. 23-32 IRAP astrophysics and planetology research institute; p. 23 Los Alamos National Laboratory (LANL); p. 6-25 Roscosmos, the Russian federal space agency; p. 23-26 IAS aerospace training institute; p. 23-26 LESIA space and astrophysics instrumentation research laboratory; p. 35 Bern University of Applied Sciences (BFH)

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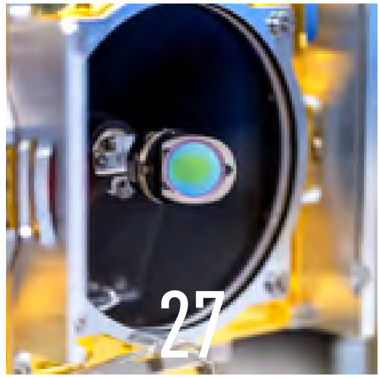

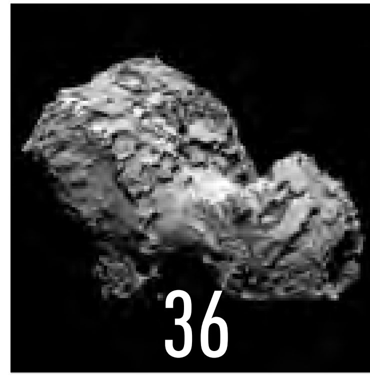

SEEKING THE SOURCES OF LIFE: A GLOBAL QUEST

CONTRIBUTORS

MICHEL VISO

As CNES's head of exobiology, Michel Viso is working on France's contributions to upcoming Mars missions that will be looking for signs of life. Engaged in establishing international recommendations to protect solar system bodies from contamination by terrestrial micro-organisms, he is currently preparing for the return of samples from the red planet.

FRANCIS ROCARD

Francis Rocard is CNES's Mars 'guru'. In charge of programmes like Rosetta or InSight and as the author of textbooks on the red planet, this astrophysicist is contributing his expertise to solar system exploration. Today he is working with science teams and focusing on ambitious future missions.

ANDRÉ DEBUS

When he first arrived at CNES, André Debus was a young engineer with a PhD in material physics working on a Mars exploration project. Since 2005, he has occupied a number of posts before becoming project leader for the European ExoMars programme. He shed light for us on SuperCam and showed us how seriously these missions are taking the ethical and environmental issues involved.

MAGALI DELEUIL

Formerly science lead for the exoplanets programme of the CoRoT space mission, astrophysicist Magali Deleuil from the LAM astrophysics laboratory in Marseille is today in charge of France's contribution to CHEOPS and PLATO, two European space observatories dedicated to delving deeper into the heavens. She persuaded us to look at the value of exoplanet research, notably on Earth 'twins'.

CNES MAG

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EDITORIAL

Where is life's place in the picture?
Where did life come from? Are we alone in the universe?

These two closely related questions have reached beyond the realm of philosophy and are now being subjected to scientific investigation in more precise terms. Attempting to answer them is like putting together a jigsaw puzzle in which each piece lies at the end of a treasure hunt. This summer, three space missions—Hope for the United Arab Emirates, Tianwen 1 for China and Mars 2020 Perseverance for the United States—are set to depart for Mars in search of new clues to solve this rebus. Others are in preparation, notably ExoMars to be launched by Europe and Russia in 2022 and the Mars Sample Return mission by Europe and the United States towards the end of this decade. Thanks to the sum of talents of the scientists, engineers and technicians working in our research laboratories, agencies and private firms, Europe and France are pivotal players in this fantastic quest to discover our origins and, in the final analysis, reveal the reasons behind our existence. As you will see in this issue of CNESMAG, large space telescopes, planetary exploration and in the months ahead in-depth study of Mars are set to deliver unique new insights into this ultimate enigma.

JEAN-YVES LE GALL
CNES PRESIDENT

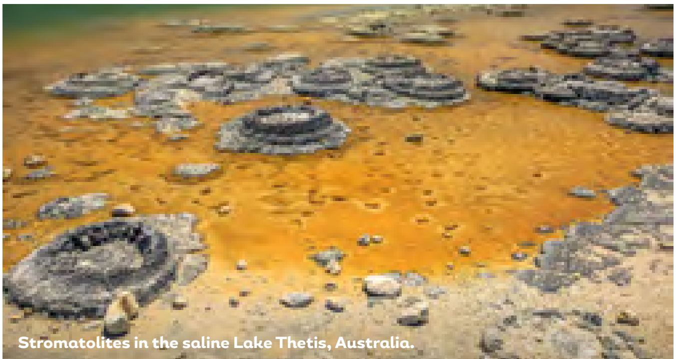
When the Mars 2020 mission lifts off, Curiosity will have been climbing the foothills of Mount Sharp for nearly eight years. While the two rovers look the same, Perseverance (pictured) has a host of improvements like the SuperCam instrument, for example, drawing on lessons learned from Curiosity.

2020

All set for a Martian summer

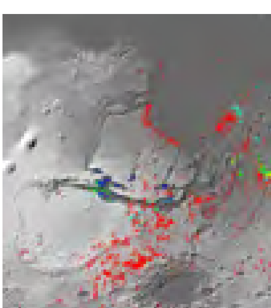
Opportunities to send spacecraft to Mars are dictated by the relative positions of the planets. Launch windows open only once every 26 months and last about two weeks. Between the end of July and early August, three missions[1] will be on the pad and ready to go: Hope for the United Arab Emirates, Tianwen-1 for China and Mars 2020 for the United States. Launched this summer, Mars 2020 plans to land the Perseverance rover and its seven instruments in Jezero Crater in February 2021, among them the French-U.S. SuperCam. The rover will have the dual mission of hunting for biosignatures to establish the red planet's past habitability and collecting and caching samples to be retrieved by the future Mars Sample Return (MSR) mission. Mars 2020 will also be paving the way for crewed missions to Mars with the MOXIE experiment to produce oxygen from Martian carbon dioxide (see CNES in Action p. 25).

1. A fourth launch was initially planned for ExoMars, but ESA and the Russian federal space agency Roscosmos have pushed it back to 2022.


Stromatolites in the saline Lake Thetis, Australia.

EXOBIOLOGY
SEARCHING FOR THE SOURCE OF LIFE

If we were to tell the history of life on Earth like a story, it might begin with the words "*once upon a time*". But it is no ordinary story, more a gripping thriller packed with numerous clues and red herrings, of which the first episode—the origin of life—still holds many mysteries. Indeed, determining how life came about is such a complex business that since the 1960s a whole new field of study has emerged: exobiology, also known as astrobiology.
This interdisciplinary domain studies the conditions and processes—complex and random chemical phenomena—that led to the emergence of life. But chemical reactions require water and energy to enable all living things to exchange matter with their surrounding environment and transform it for their own benefit. According to recent research, it was light energy that triggered the prebiotic chemical reactions leading to life as we know it.



100,000

A map of Mars compiled in 2020 shows sites bearing hydrated minerals—phyllosilicates, clays, hydrated sulphates, polyhydrated salts and carbonates. So far, 100,000 such sites have been identified.

Source: J. Carter, IAS.

WATER AND CARBON
GALACTIC CRACK DUO

With one oxygen atom and two hydrogen atoms, water is a chemically very simple compound. It is found everywhere in the universe, in gaseous, frozen and liquid states. Water has been detected on many planets in the solar system, as well as at the core of galaxies and in interstellar clouds. In its liquid form, it plays a key role in the chemical reactions that led to the emergence of life on Earth.
On Mars, with the discovery of traces of water having once flowed on its surface, scientists are now seeking to determine if it could have supported chemical reactions conducive to creating forms of life. Carbon, on the other hand, forms organic molecules with hydrogen and oxygen atoms and is the other vital ingredient of life. Carbon and liquid water are thus the two elements of the equation to be solved to explain where life came from.

CHIRALITY

LEFT- AND RIGHT-HANDED MOLECULES

Take a few seconds to join your hands together. You'll see that they mirror each other. Now try putting them one on top of the other—they no longer match. A left-hand glove doesn't fit the right hand and vice versa. Some chemical molecules are the same. That is, despite having perfectly identical formulas and properties, they exist in two non-superimposable forms. By convention, these so-called chiral forms[1] are designated left- and right-handed. In the laboratory, chemical synthesis produces as many right-handed as left-handed forms.
On Earth, all living organisms fabricate and use only left-handed forms of amino acids and right-handed forms of sugars. So, finding a single form of chiral molecules on a planet would be a very strong indicator that life had developed there. The SAM (Sample Analysis at Mars) instrument on board the Curiosity rover is a veritable laboratory analysing Martian samples collected in situ and able to detect infinitesimally small amounts of these chiral compounds.

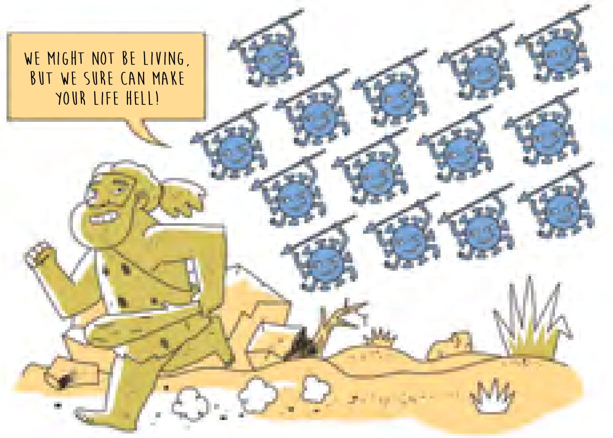
1. From *kheir*, the Greek word for 'hand'.

BIOSIGNATURES

DIPPING INTO THE UNIVERSE'S TOOLBOX

For all you DIY enthusiasts out there, were you to find a size-12 spanner on Mars, while it contains neither carbon nor nitrogen, you could nevertheless conclude that there is life on the red planet. Not necessarily a Martian lifeform, but rather that someone had been there before you. This analogy clearly illustrates the principle of what we call a biosignature, which proves the presence of a form of life. To understand life on Earth, scientists are combing the universe for signs of other lifeforms. Detecting, identifying and interpreting biosignatures is like a treasure hunt, as they may take the shape of crystals, biominerals, organic molecules preserved in soil, or gaseous compounds trapped in rock or accumulated in the atmosphere. Hunting for biosignatures is therefore akin to looking in the universe's toolbox for the 'size-12 spanner' left behind by a form of extraterrestrial life.

Microfossils in a sediment core extracted by the Deep Sea Drilling Project (DSDP).



LIFE
A BEGINNER'S GUIDE

Viruses may circulate, but are they living things? For scientists, the answer is a resounding 'no'. Bacteria, on the other hand, *are* living things. The difference lies in four features. The first is that living things create themselves by themselves. What that actually means is that "if I eat lettuce, I don't turn into a lettuce: I transform an element of my environment into a part of me," explains CNES exobiologist Michel Viso. The second is multiplication. A living thing has the ability to 'make' new individuals. Bacteria divide and living things use the ability conferred by the first feature to go forth and multiply. And through reproduction, living things transmit genetic information almost identical to their own… the third feature. 'Almost' identical, because genetic mutations are what bring us to the fourth and final feature, which is that living things evolve. Life can't exist outside these four conditions.

96%

Near its surface, the atmosphere of Mars is composed approximately of 96% carbon dioxide, 2% argon, 1.9% nitrogen and traces of oxygen, carbon monoxide, neon and krypton. Atmospheric pressure is variable and less than 1% that of Earth's.

1,000 W/m²

A planet is in the habitability zone when the amount of energy it receives enables water to persist in liquid form. This is so on Earth, which receives about 1,000 W/m² of energy from the Sun.

35 million km²

Mars is prone to violent dust storms with winds reaching up to 108 km/h. The storm of June 2018 covered some 35 million square kilometres, i.e. a quarter of the planet's surface, shutting down operations of the Opportunity rover.

EXOBIOLOGY DISCOVERIES OF SPACE MISSIONS

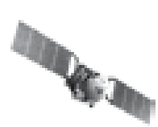
1975-1981

Viking 1 & 2
First in-situ attempt to look for signs of life on Mars.

1997-2017

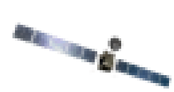
Cassini-Huygens
Orbiting Saturn from 2004, the mission reveals plumes spraying from the surface of Enceladus (see In Pictures, p. 17).

2003-active



Mars Express
The spacecraft's OMEGA imaging spectrometer detects clays on Mars.

2004-2016



Rosetta
The first spacecraft to go into orbit around a comet (67P-Churyomov-Gerasimenko, see Roundup p. 10)

2006-2014

CoRoT
The space telescope discovers exoplanet CoRoT-7b, a sort of 'super Earth' (see In Figures p. 18).

2009-2013

Herschel
The space telescope deciphers how stars are born and formed.


Gale Crater, with Mount Sharp at its centre.

SAM
ORGANIC MOLECULES UNDER CLOSE ANALYSIS

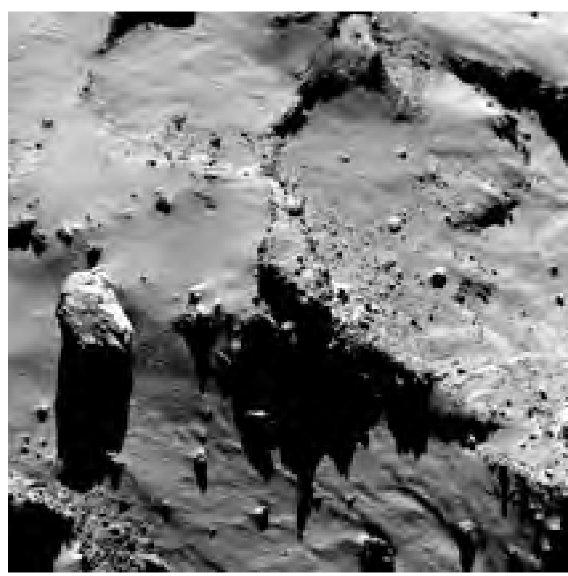
The Opportunity and Spirit rovers on NASA's Mars Exploration Rover mission (2004-2019) proved that liquid water flowed on Mars three and a half to four billion years ago. Forthcoming missions[1] will perhaps find evidence of past life. In the meantime, Curiosity has been studying Mars' habitability since 2012 with its French-U.S. SAM laboratory. SAM comprises three complementary analytical instruments, including a gas-phase chromatograph (see Spinoff p. 36) developed by the LATMOS atmospheres, environments and space observations laboratory and the LISA inter-university laboratory for the study of atmospheric systems with oversight from CNES. In 2014, SAM revealed the presence in Martian soil of molecules containing up to 12 carbon atoms, as well as hydrogen, oxygen and sulphur, all elements capable of forming pre-biotic organic molecules. It also uncovered intriguing seasonal variations in concentrations of methane in the atmosphere. It is now pursuing its analyses on samples obtained from different layers of Mount Sharp, at the centre of Gale Crater. Over the next two years, scientists will be eagerly awaiting the results as SAM explores the mountain's clay- and sulphate-bearing layers.

1. ExoMars 2022 and Mars Sample Return (MSR).

COMET CHURY
ROSETTA'S REVELATIONS

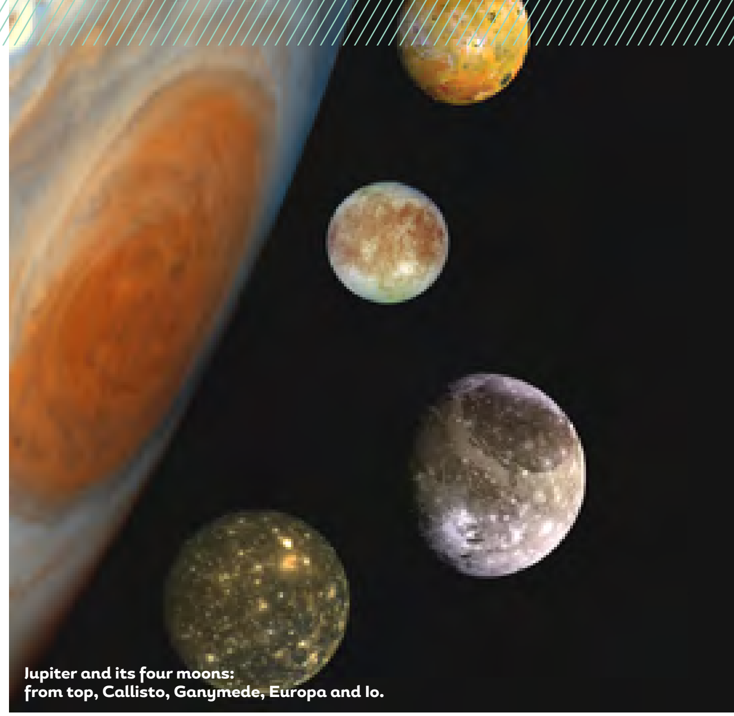
In 2016, Philae landed on comet Churyomov-Gerasimenko, nicknamed 'Chury'. It shut down three days later, but the Rosetta spacecraft that had put it on the comet's surface continued collecting data. Its searches showed that deuterium, an isotope[1] of hydrogen, is five times more abundant in the comet's water molecules than on Earth, a result that adds weight to the theory that comets might have seeded our planet with water. While this hypothesis complicates our understanding of how the solar system formed, it can't be excluded. The abundance of isotopes of elements like xenon points to comets possibly having played a role in forming Earth's atmosphere. Organic molecules like glycine, the simplest amino acid, have also been found in Chury's environment. And measurements suggest that its nucleus, composed of a variety of ices (CO_2, water and ammonia) and rocks, contains abundant organic macromolecules.

1. Atoms with the same atomic number but different atomic mass.



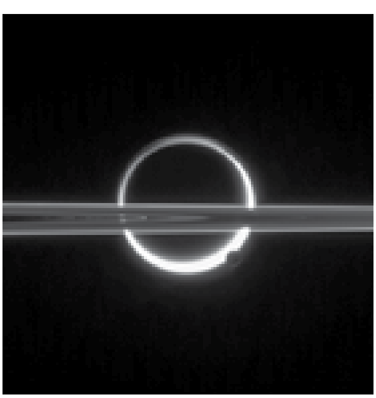
JUICE
DIVING INTO JUPITER'S OCEANS

Galileo first affirmed as far back as 1610 that Jupiter and its moons were a scaled-down model of the solar system. Since then, several spacecraft[1] and two U.S. missions—Galileo in 1995 and Juno still in orbit—have sought to penetrate the Jovian world.
The JUICE mission selected for ESA's Cosmic Vision programme (2015-2025) is now set to pursue the task. It will study close up three of Jupiter's Galilean moons: Europa, Ganymede and Callisto. Why these moons in particular? Because they all have oceans that have yet to give up their secrets. What are these oceans' features and environment? Are they large, small, deep? Ganymede's is thought to lie under 100 kilometres of ice and be up to 700 kilometres deep.
Could Europa's, which is easier to reach, be home to environments on a par with deep ocean habitats on Earth? JUICE will also continuously probe Jupiter's atmosphere and magnetosphere, and its interactions with its moons. The payload will include several French instruments, including spectrometers and a radar, for which CNES is prime contractor. Launched in 2022, it will reach Jupiter in 2030 and spend three years there before going into orbit around Ganymede.


Jupiter and its four moons: from top, Callisto, Ganymede, Europa and Io.

1. Pioneer, Voyager.

CASSINI-HUYGENS
JOURNEY THROUGH SATURN'S MOONS



During its 20-year odyssey from 1997 to 2017, Cassini-Huygens[1] visited Saturn and its moons Titan and Enceladus, changing the way we see the solar system forever. Like Earth's atmosphere, Titan's is chiefly made up of nitrogen but also contains methane and organic compounds. Titan shares other features with Earth, such as a diverse geology of dunes, mountains and volcanoes, an atmosphere with clouds and rain, and liquid methane and ethane seas and lakes. Enceladus has been found to have giant plumes spraying from its surface (see In Pictures p. 17), which are thought to be coming from a subglacial ocean. These jets of water vapour and ice grains, similar to the hydrothermal vents in Earth's ocean ridges, could be 'habitable' zones where the environment might support life.

1. Planetary exploration mission (NASA-ESA-ASI).

#COMMUNITY

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@KALGAN_

#CSTI science educator and fan of #physics #chemistry #space and #chocolate. Likes storytelling. Digital disruptor. Talks in @Safran and, previously, @cnes

Until 1995, the solar system was the only planetary system we knew. That large planets might exist orbiting close to their star was unimaginable, going against the consensus on planetary formation. The discovery of the first exoplanets rewrote the textbooks on this. #cnestweetup

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Ah yes, tomorrow's world 📣 Sign up to our new newsletter #Règle30 ! 📫
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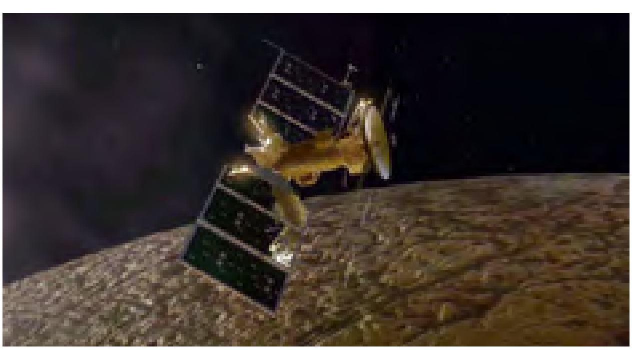
Is there life on Europa? NASA has given the go-ahead for its mission to Jupiter's icy moon https://buff.ly/2Hgmz00



@SIMONCHODORGE

Early-rising journalist @usinenouvelle • Industry, literature, cinema • Passionate about #SFFF • Previously with @lesinrocks and @WeDemain • DMs open.

Searching for life on Mars: a long-haul, complex and uncertain adventure, but above all an exciting one. At @CNES, an exobiology expert was explaining the stakes of the #Mars2020 mission.

@THOMALDEBARAN

PLATO will be departing in 2026 to detect Earth-like exoplanets 🌎 around Sun-like ☀️ stars✨. #CNESTweetUp

Q & A

YVES COPPENS

IN HIS QUEST TO DISCOVER MAN'S ORIGINS, paleontologist and paleoanthropologist Yves Coppens is a spectator of life and its evolution. He sheds light for us on how space is bringing us new insights into the emergence of life as we know it.

WHAT DO WE KNOW ABOUT THE ORIGIN OF LIFE ON EARTH?

Yves Coppens: What we know is based on paleontological evidence from remnants of living things and on the expertise of physicists who date them. According to the oldest traces of life yet found, which resemble microbial cysts like those in the rocks in the Isua Greenstone Belt in Greenland, we can say the transition from inert to living matter occurred approximately four billion years ago.

YOU HAVE DISCOVERED SIX SPECIES OF HOMINID. WHERE DO HUMANS FIT INTO THE PICTURE?

Y. C.: The first thing to understand is that all living things are our cousins, since we all descend from the same original cell. In these four billion years of evolution, our story spans 10 million years, which is the age of the common ancestors our lineage shares with chimpanzees. A major change in Earth's climate was triggered by an astronomical event, giving birth to the Antarctic and making tropical forests less dense. In this new and more open environment, pre-humans like Toumaï and Orrorin adapted by walking upright but continued to climb trees. Then, three million years ago, another change in the climate created the Arctic and again led to much drier conditions in the Tropics. Pre-humans like Lucy adapted by developing a larger skull and brain, probably out of the need in a landscape increasingly devoid of cover to find strategies to escape the clutches of predators… They then became Man, or Homo, capable of thinking ahead, about themselves and others, about the environment and above all about death. All human facets were therefore in place three million years ago.

WHAT DOES EARTH TELL US ABOUT THE POSSIBILITY OF LIFE EMERGING ELSEWHERE?

Y. C.: Life as we know it is a superior development of the matter contained in our solar system. We know that several conditions are necessary for a living being to emerge. The exceptional development of life on Earth, for example, is down to the fact that it lies 150 million kilometres from the Sun. This distance, combined with their respective masses, was sufficient for our planet to retain its atmosphere and water, unlike Mars, which is much smaller and where water may still be present below the surface but no longer in the atmosphere. So, we can cautiously affirm that life seems to have appeared on Earth or, if it was seeded here, that it comes from our solar system, because other systems are too far away. In this living world, which is just 4.6 billion years old like our Sun, at another scale we are also made of stardust as astronomers so poetically put it. And stars are being born in the universe every day.

> "EVOLUTION IS THE ADAPTATION OF LIVING BEINGS TO AN ENVIRONMENT."

DOES UNDERSTANDING HOW LIFE EMERGED HELP US TO UNDERSTAND HOW IT EVOLVED?

Y. C.: The extraordinary thing is that once life is established, it has the faculty to reproduce—initially by simple cell division—and thus colonize the whole planet as it adapts to the environments it encounters. We paleontologists are historians of Earth: we see how this nascent biodiversity evolved, for example through rocks like stromatolites made up of fossil living things at epochs close to the time when life emerged. The urgency with which life reproduced and its immediate obsession with its own self-preservation are indeed impressive. That's why there are so many pollen grains in a flower and so many cherries on a single tree: life fabricates a lot of reproductive elements to be sure that enough will survive. Remember that a living being is defined by itself and its environment, without which it cannot survive: evolution is the adaptation of living beings to an environment, and new adaptations when that environment changes, which happens all the time as a result of climate change (itself the result of astronomical changes).

YVES COPPENS

PALEONTOLOGIST
AND PALEOANTHROPOLOGIST

"THE TRANSITION FROM INERT TO LIVING MATTER OCCURRED APPROXIMATELY FOUR BILLION YEARS AGO."

WHAT DISCIPLINES DO WE NEED TO ADVANCE IN OUR SEARCH FOR THE ORIGIN OF LIFE?

Y. C.: Astronomy first and foremost, since everything starts with the solar system. Other disciplines logically follow on from there to retrace the origin of life: geology, biology (or paleontology) and lastly anthropology (or paleoanthropology) when searching for our own origins.

DO YOU USE SATELLITE DATA FOR YOUR RESEARCH?

Y. C.: Of course, especially to locate paleontological sites of interest. When looking for fossils, paleontologists always start with a geological survey, as collecting fossils is of no use without knowing what sedimentary layer they come from. From space, we can distinguish sedimentary from crystalline terrain, and we can estimate ages from rock weathering. When I started my research in Chad in 1960, I had 1:1 000 000-scale maps of a region as big as France and aerial topographic surveys that had never been checked on the ground! Today, satellite imagery allows us to outline fossil terrain and then locate sites of interest with GPS coordinates.

COULD EXPLORING MARS SHED LIGHT ON THIS "LOST" CHAPTER IN EARTH'S HISTORY?

Y. C.: I'm sure it will, but not only Mars. Other planets could have supported life and in that case must have preserved clues on how it appeared and disappeared. That's the job of exobiologists. Planetology and astrophysics are bound to bring many benefits for paleontology.

DO YOU THINK A FORM OF LIFE COULD HAVE DEVELOPED ON AN EXOPLANET OUTSIDE OUR SOLAR SYSTEM?

Y. C.: In conditions not similar to but comparable to those on Earth, it's quite possible. Life on Earth developed by making choices at each branch point to adapt, leading to our own evolution, but on another planet the evolutionary choices would undoubtedly not have been the same. Life elsewhere would therefore most likely look quite different to what we know, with strange beings I would be very eager to meet!

Profile

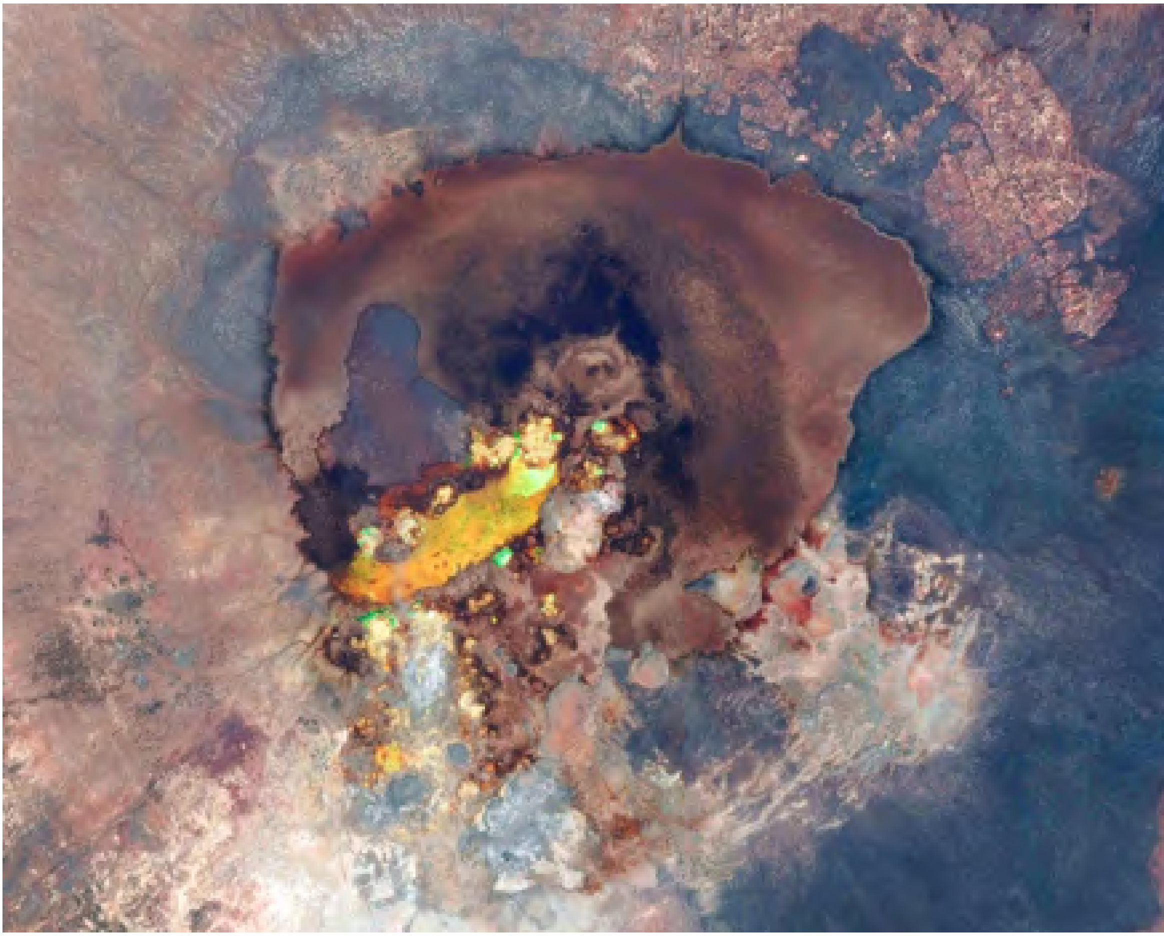
1956
Joins the French national scientific research centre CNRS

1961, 1967, 1974
Discovers *Tchadanthropus uxoris*, co-discovers Aethiopicus and Lucy

1975
Discovers that man was born out of the need to adapt to climate change

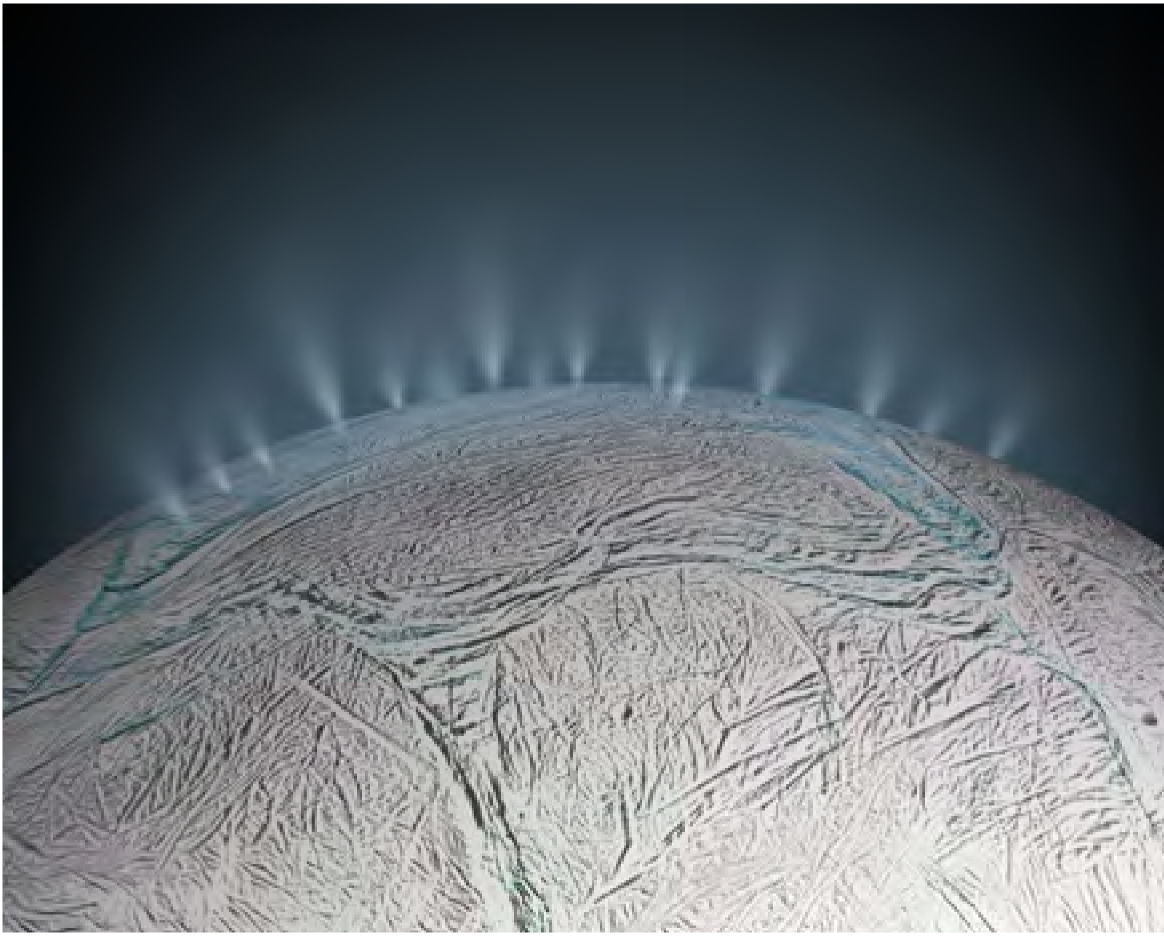
1983
Professor at the Collège de France

1995, 2001, 2002
Co-signatory of Abel, Orrorin and Toumaï



LIQUID WATER IS NOT ENOUGH

Both entrancing and foreboding, the Dallol hydrothermal system formed in Ethiopia's salty Danakil Desert. While microbial life on Earth has adapted to extreme temperature, acidity and salinity conditions, Dallol is the only place that combines all three. The verdict of recent scientific research is that there is no life in the dome's hyper-saline, hot (up to 108°C) and hyper-acidic pools, or in the adjacent magnesium-rich brine lakes. What this is telling planetary explorers is not to be tricked by biomorphs, that is, minerals shaped like cells. On the other hand, life does exist in the form of single-celled micro-organisms called archaea at the base of the dome, in the salt flat and in the lake below.



SMALL MOON, BIG PLUMES

These gigantic plumes spewing high above the surface are coming from the south pole of Enceladus, Saturn's icy moon. First discovered and then flown through by the Cassini spacecraft, the plumes contain ice and several organic compounds that suggest the moon harbours an interior liquid ocean with a rocky bottom. With carbon compounds, sodium salts, methane and hydrogen, Enceladus—like Earth four billion years ago—has all the conditions for submarine volcanic activity. Studying its geysers could therefore support the theory that the building blocks of life first appeared in underwater hydrothermal springs—and all without even having to dig!

IN FIGURES

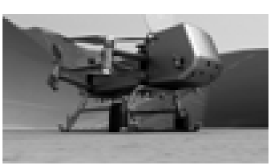
BIG SISTER

Discovered by CoRoT, a CNES/ESA spacecraft, CoRoT-7b is a rocky planet 1.7 times larger and five times heavier than Earth. **On its day side, temperatures reach a searing 2,500°C, while on the night side they plunge to –240°C. It orbits 2.5 million kilometres from its star, whereas Earth is 149 million kilometres from our Sun. A year on CoRoT-7b therefore lasts just 20.4 hours.**

2,600

The Kepler spacecraft holds the record for the number of exoplanets detected at 2,600. In July 2015, it had already smashed previous records, adding 1,284 planets to the tally of 2,125 already known.

DRAGONFLY



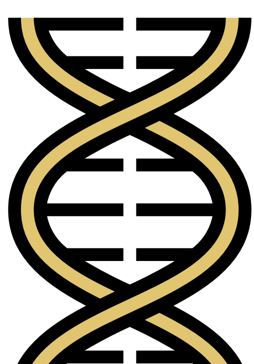
Titan is truly an open-air chemistry laboratory. Its atmosphere is four times denser than Earth's and its composition is today similar to that of the very early Earth. For two and a half years, NASA's Dragonfly rotorcraft-lander is set to investigate Titan's organic surface materials and search for the missing links between prebiotic chemistry and life.
Another of the mission's advantages is that where a rover can only scout a few kilometres, Dragonfly will cover several hundred.
One of the four instruments on its payload will be DraMS (Dragonfly Mass Spectrometer), designed to identify soil molecules. If forms of life once existed or are still present on Titan, it should find its signatures. The mission is scheduled to lift off in 2026 and land in 2034.

2,316

CASSINI-HUYGENS, a joint mission of the U.S., European and Italian space agencies, harvested a wealth of data. In 2017, when it took its final plunge, it had already yielded data for 2,316 research papers.

Alphabet soup

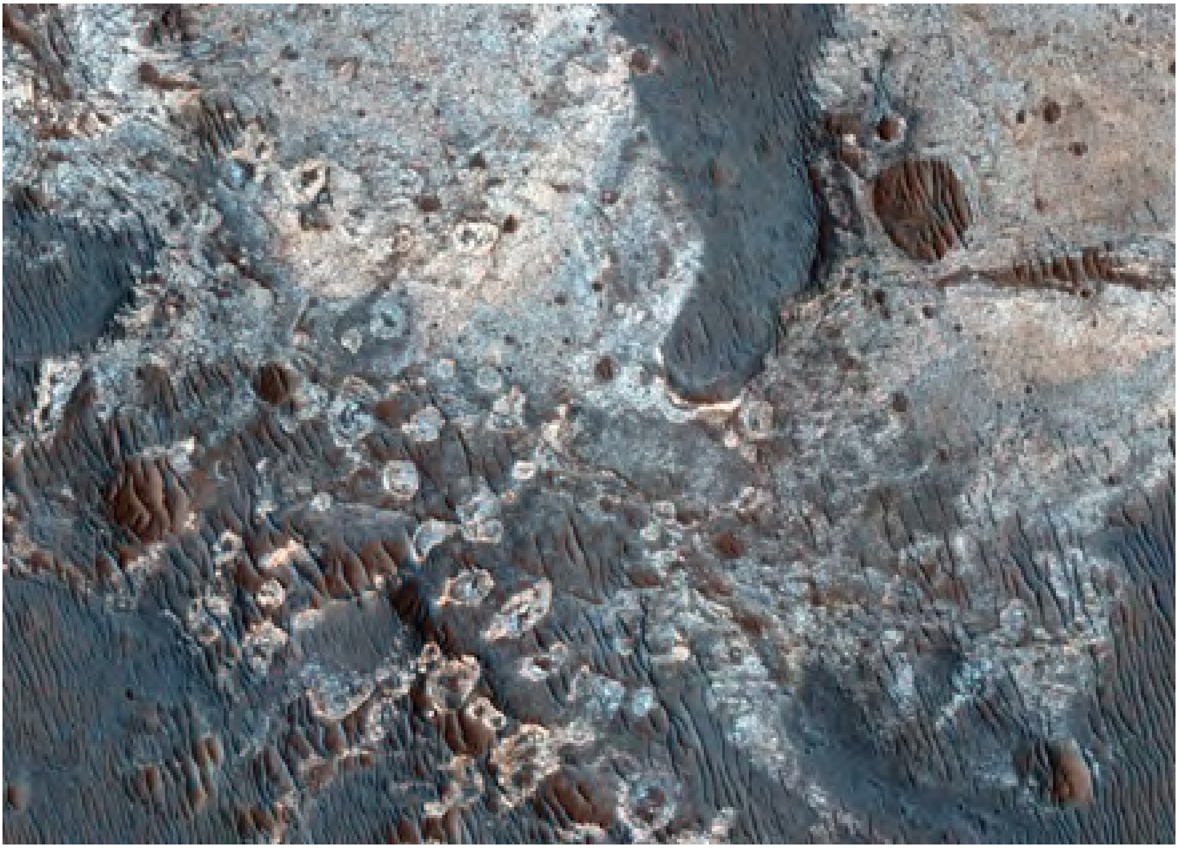
LIFE ON EARTH SYNTHESIZES NO MORE THAN 20 AMINO ACIDS. Their precise sequence determines the properties of each protein, encoded by nucleic acids that carry the genetic information transmitted from generation to generation with a four-letter code–ATCG–in which each letter represents a specific compound (adenine, thymine, cytosine and guanine). The information contained in the genome of living cells is translated using 'words' essentially composed by three of these letters. The discovery of sugars, amino acids and precursor elements of genetic code in certain meteorites suggests they were already present when the solar system formed...



The flight model of SuperCam being integrated at IRAP in Toulouse.

UNRAVELLING THE MYSTERY OF LIFE

WHERE DO WE COME FROM? ARE WE ALONE IN THE UNIVERSE? THESE QUESTIONS THAT HAVE BEEN TAXING OUR MINDS FOR CENTURIES REMAIN UNANSWERED. MISSIONS TO MARS IN WHICH CNES IS PLAYING A PRIME ROLE HOPE TO FIND THE FIRST CLUES TO A NEW UNDERSTANDING. FOR WHAT BETTER PLACE IS THERE THAN SPACE TO HELP SOLVE THIS ENIGMA?



Signatures of clays in Coprates Chasma, a vast system of canyons near Mars' equator. The weathering of the plains and their alteration into clays proves that water once persisted here for long periods.

Humans have forever turned their gaze to the gods and stars in seeking to understand where life on Earth came from. Science prefers exploration over incantations, and it is searching space for signs of primitive life precisely because here on Earth they have long been erased by plate tectonics, flowing water and ultraviolet radiation. So, why Mars? Far from looking for 'little green men', there is a very rational explanation. "While Mars is at the very edge of the solar system's habitable zone, it's relatively easy for space probes to get to," explains astrophysicist Francis Rocard, CNES's Mars 'guru'. "Venus is closer, but far too inhospitable!" What's more, it's thought that Mars' atmosphere was produced by similar conditions to those on Earth and traces of water have been identified there, all factors that point to it as a destination of choice.

TREACHEROUS BEGINNINGS

Mars' red hue is readily apparent at certain periods and had already attracted astronomers' attention in Antiquity. Much later, Galileo made the first observations of the planet by telescope in 1610. In the 1960s, U.S. and Soviet space missions were the first to get up close and personal with Mars. This exciting adventure also proved complex and perilous, as probes faced severe weather conditions, span out of control

or landed with a bump or even crash. More than half of Mars missions have been failures, making those that succeeded all the worthier of praise. Two that stand out in particular are Mariner 9 (NASA, 1971), the first spacecraft to go into orbit around a planet other than Earth, which discovered Mars' volcanoes and canyons, and the Viking missions (NASA, 1975), which marked the start of in-situ robotic exploration and the first spacecraft to land on its surface.
For technological, scientific, political and budgetary reasons, the Mars odyssey then went through a 20-year hiatus. It was not until 1996 that the stunning images beamed back from Mars Global Surveyor —the first in high resolution—refired interest in the red planet. The same year, the U.S. Mars Pathfinder mission landed a base station and its small Sojourner rover.

A QUEST WITHOUT BORDERS

In Japan, India, the United Kingdom, Russia and across the globe, scientists are seeking to shed light on life's origins. Mars is the focal point for science missions in many countries, and Europe's space programme is devoting the necessary resources to join this adventure. In 2003, it launched Mars Express to collect data on the surface, atmosphere, ionosphere and subsurface of the planet with the hope of solving the mystery of how life formed. Engaging in such extensive endeavours is in CNES's culture. Astrophysicist Jacques Blamont, CNES's first Director of Science and Engineering who passed away recently, was a driving force behind the agency's involvement in these avant-garde projects. From designing balloons for Venus and Mars to developing space probes, he spurred the culture of solar system exploration that persists to this day. Since the 1990s, all missions to Mars have carried instruments that CNES has at least partly overseen.

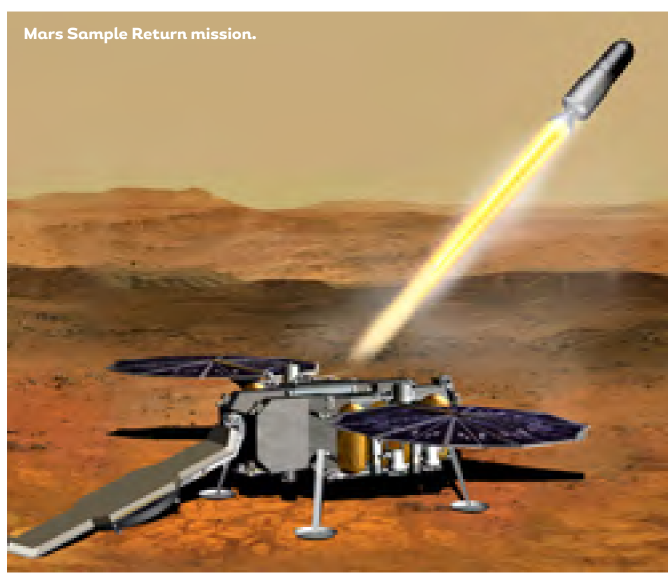
AN EXISTENTIAL QUESTION

And this effort isn't about to stop anytime soon. NASA's Mars 2020 and ESA's ExoMars mission in 2022 will be carrying suites of instruments to which CNES has contributed a great deal of its expertise. The agency will also be on board the key Mars Sample Return (MSR) mission in preparation alongside Mars 2020. Three successive missions (see Timeline p. 28-29) will in fact be required to bring back Martian samples for in-depth analysis on Earth. While in-situ exploration by human crews is still a long way off, these missions are nevertheless inexorably taking us in that direction. But that doesn't mean Mars is a planet B to replace an endangered planet Earth. To the climate sceptics who find refuge in the idea that we will one day colonize Mars, Francis Rocard replies: "The only habitable planet we know for humans is Earth." So "why look for another form of life? How will that benefit us?" he asks, a tad provocatively. The answer is not only scientific, but also humanistic. "Imagine what an intellectual and philosophical revolution would be sparked if we find signs of life on Mars. Will it be built on DNA like all organisms on Earth? Or are there diverse forms of life in the universe?" While such exciting or mind-boggling existential questions might not trouble robotic payloads, they nevertheless remain in the back of scientists' minds.

43

Mars has been visited

43 times by probes, orbiters and landers since the 1960s. Out of all of these missions, there have been 22 failures or semi-failures for 21 real successes. Odyssey, MEX, MRO, TGO, InSight, Curiosity, MAVEN, Mangalyaan, Mars Express and InSight are ongoing, and four more missions are set to join them in 2020 and 2022.



Mars Sample Return mission.

Perseverance undergoes integration tests in the simulator at the Jet Propulsion Laboratory (JPL) in Pasadena, California.

MARS 2020
A MISSION WITH **MULTIPLE GOALS**

The long history of the search for other forms of life has been written by Mars missions.
With the Perseverance rover, NASA and its partners are about to embark on the whole new adventure of bringing back Martian samples to Earth.

This summer, a window opens for launching Mars 2020 towards the red planet. This mission is the logical next step for NASA after its pioneering Spirit and Opportunity twin rovers, which landed in 2003, and their big brother—six times larger—Curiosity, which began surveying the surface in 2012 for the Mars Science Laboratory (MSL) mission. Still operational after Opportunity shut down in February 2019, Curiosity will pursue its investigations while the aptly named Perseverance begins its mission at a location several thousand kilometres away.

13 mm

That's the diameter of a thick pencil

and of the tubes designed to hold samples of rock obtained with Perseverance's drill. These 60-mm-long tubes will be filled and then sealed to protect their contents from contamination.

MULTIPLE AMBITIONS

Mars 2020 will have a packed work schedule to accomplish. Its first goal concerns exobiology and Mars' geology, in an effort to elucidate how the planet evolved through analysis of chemistry, minerals and any organic molecules it might detect. The U.S. space agency also wants to "determine whether a form of life could have developed in the past," says CNES exobiologist Michel Viso. "For that, we need to find if there are traces of biosignatures or characteristic chemical elements that have been preserved." Mars 2020 will be surfing the wave of previous discoveries such as those by Curiosity confirming that the frozen desert landscape we see today was once habitable, and finding organic molecules in sedimentary rocks. Perseverance, whose design is based on Curiosity's, is carrying instruments geared towards looking for signs of ancient life, notably SuperCam (see Materials p. 27). The mission is also carrying MEDA[1], a suite of weather sensors that will measure ground and air temperature, pressure and humidity, wind speed and direction, and monitor dust particles in suspension. Perseverance will also be taking with it Ingenuity, an experimental helicopter developed by NASA. Once on Mars, this 1.8-kg craft will fly autonomously to perform short optical reconnaissance missions.

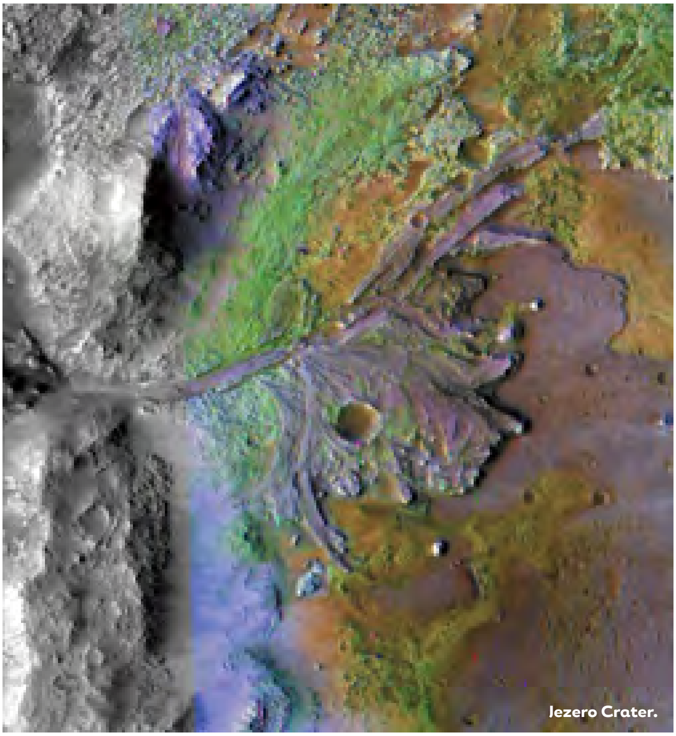
1. Mars Environmental Dynamics Analyzer.

SUPERCAM

PACKED WITH INNOVATIONS

The ChemCam instrument on board the Curiosity rover has made key discoveries about Mars' geology and found evidence that water once flowed on its surface in the distant past. SuperCam, developed in partnership with Los Alamos National Laboratory (LANL), CNRS research laboratories and French universities[1] with the IRAP astrophysics and planetology research institute as science lead and oversight from CNES, is set to go one better on the Perseverance rover. Perched atop the rover's mast, the Mast Unit—a French contribution—is capable of rotating through 360 degrees to provide a wide view of potential zones to explore. While drawing on ChemCam's heritage, SuperCam features some major enhancements designed to offer more analysis capabilities (see Materials p. 27).

1. IRAP, LESIA, LAB, OMP, LATMOS, IAS, ISAE.



Jezero Crater.

JEZERO

A FULL SCIENTIFIC CONSENSUS

Mars 2020 will be heading for Jezero Crater, a locality in Mars' northern hemisphere. Jezero was chosen from a field of 30 candidate sites because it combines several advantages. The first of these is to do with engineering constraints, the aim being to avoid going "too high", "too cold" or "too dangerous". The second is that the site is a good match for the mission's science goals. Since Mars 2020 will look for signs of ancient life, landing in a 'primitive' region of the planet that has preserved the record of its four-billion-year history makes sense. Jezero ticks all the boxes, as it contains sediments in the surrounding delta and carbonate-bearing rocks and clays formed by liquid water. Third and last, Jezero is home to an inlet and outlet valley, forming a complete hydrological system never observed before on Mars. The crater could therefore have held a lake that filled and emptied several times and could have been active when the crater formed 3.8 billion years ago.

A SPRINGBOARD FOR HUMAN EXPLORATION

Perseverance is also paving the way for the next episodes in the Mars adventure, in particular the first segment of the spectacular MSR sample return mission planned for 2031. But before samples can be brought back to Earth, they must first be collected. The rover will therefore be surveying Mars' soil to find sites with most science value, with SuperCam helping it to select the most interesting rocks for sampling. In all, 43 samples weighing a few grams will be deposited in small piles at different locations and MSR will retrieve just 30 of them (see Timeline p. 28-29). Finally, after the robotic missions of Mars 2020, future human exploration missions are on the horizon. For crewed missions to Mars, astronauts will have to use in-situ resources like oxygen, which will need to be fabricated. The MOXIE experiment on Mars 2020 is set to demonstrate the ability to produce oxygen from carbon dioxide in the planet's atmosphere.

10,000°C

To analyse rocks, SuperCam uses a powerful infrared laser that instantly raises the temperature at its point of impact to 10,000 degrees Celsius. This flash of light is then analysed by the instrument's spectrometers.

EXOMARS BACK TO THE FUTURE

Will there one day be a rover show on Mars? While roving vehicles are today exploring sites that are far apart, they nevertheless share the same goal of finding signs of past life on the red planet. At the controls of Rosalind Franklin, the ExoMars 2022 mission's rover, ESA and the Russian federal space agency Roscosmos will be drilling into the soil of Oxia Planum at Mars' equator.


ExoMars mission.

In 2016, the European Space Agency and its Russian counterpart placed the first element of an ambitious programme initiated in 1999 into Martian orbit with ExoMars 2016. This first mission will be followed by ExoMars 2022, set to depart when the next launch window to Mars opens on 21 September 2022 and to arrive in June 2023.

A FIRST-RATE ORBITER

The ExoMars 2016 mission carried a Trace Gas Orbiter (TGO) and a lander called Schiaparelli. While the latter failed when its final landing manoeuvre went wrong, TGO continues to survey Mars' atmosphere from its orbital vantage point. From day one, TGO proved very good at detecting and identifying atmospheric gases. It didn't find any methane, however, although this gas has been detected locally by Curiosity's SAM instrument. On the other hand, TGO has yielded information about Mars' climate, the composition of its atmosphere and how water vapour behaves there. It has also measured dust densities during the storms that sweep across the red planet. With its two spectrometers, the orbiter has compiled the most detailed inventory yet of atmospheric trace gases. The stereo camera has obtained spectacular pictures of the surface and notably traces of dust devils, while the neutron detector is patiently measuring water content in the first metre of Martian soil. TGO is also serving as a telecommunications relay between Earth and systems on the surface of Mars. For example, it sends back data from Curiosity in a supporting role to U.S. satellites. It also occasionally transmits data from the French SEIS seismometer on the U.S. InSight lander. With such a distinguished service record, TGO will be pursuing its missions and standing ready to relay data from ExoMars 2022.

316 kg

The mass of Rosalind Franklin,
a lightweight for a Mars rover. It will be carrying a 26-kg payload. In comparison, Curiosity tips the scales at 899 kg and Perseverance weighs more than a tonne.

HEADING FOR OXIA PLANUM

For ExoMars 2022, the Russian Kasachok surface platform will survey Mars' geology and meteorology, while the Rosalind Franklin rover, a veritable mobile laboratory, will search for signs of life. Sitting atop the platform, the rover and its nine instruments will egress after landing to begin its science mission. It will be carrying infrared, Raman[1] and neutron spectrometers, cameras and instruments for fine chemical analyses, as well as a gas-phase chromatograph and a mass spectrometer. Overseen by CNES, French research laboratories are supplying two instruments—a spectrometer and radar—and contributing to three others. But the rover's truly revolutionary feature is its drill. Rosalind Franklin will be set down in Oxia Planum, chosen on the strength of data obtained from the OMEGA[2] instrument on Europe's Mars Express orbiter and other U.S. instruments. The clay-bearing soils there are about four billion years old and conditions similar to those in which life emerged on Earth. However, cosmic radiation may have altered any interesting chemical compounds that could have been deposited on the surface. The science team is therefore going to look deeper, using the drill to obtain core samples down to two metres that will then be conveyed to the rover's laboratory to look for potential biosignatures—a first on Mars. To select the best sites for sampling, Rosalind Franklin will be all-terrain, thanks to its six articulated driving wheels designed to overcome obstacles in its path.

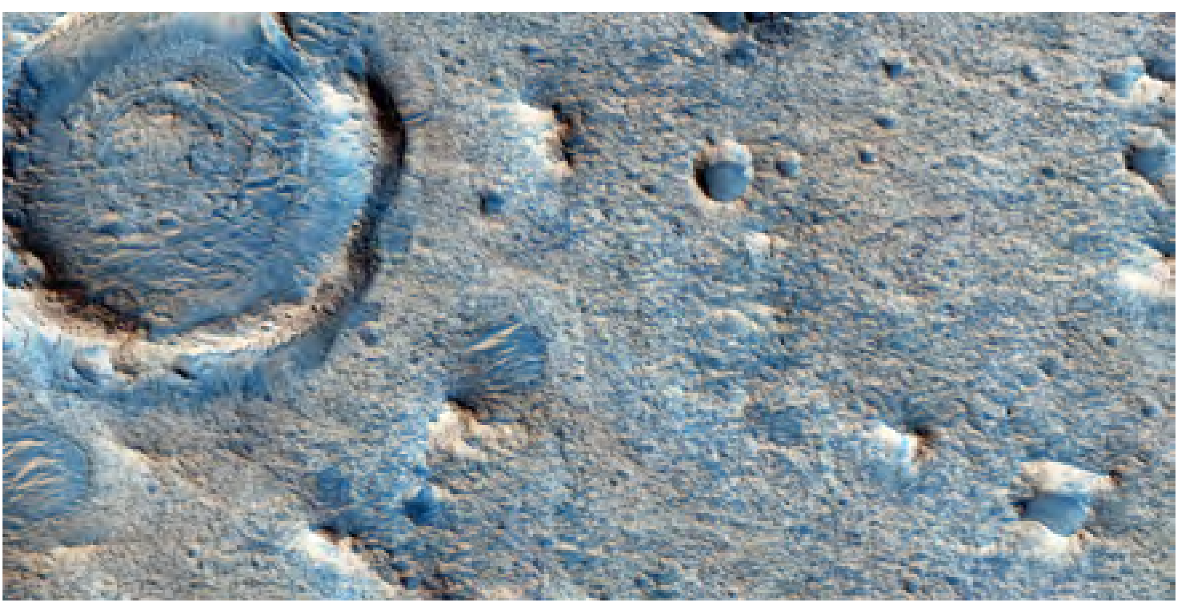
36,000

Names for the ExoMars 2022 rover

submitted to the UK Space Agency (UKSA) by citizens from ESA's member states. Rosalind Franklin was a chemist and physicist who made a crucial contribution to the discovery of the double-helix structure of DNA. The rover's name thus pays tribute to this British scientist who played a key role in our understanding of genetics and therefore life.

1. Non-destructive method for observing and characterizing a material.
2. Instrument developed by IAS, LESIA and CNES.

Oxia Planum.

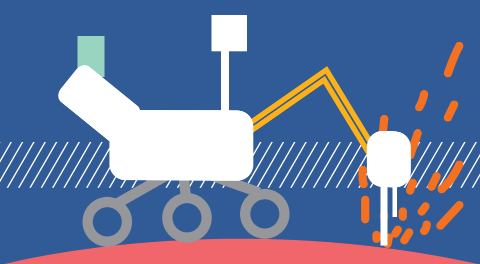


SUPERCAM FIVE TOOLS IN ONE

THE MARS 2020 MISSION'S SUPERCAM HAS QUITE A FEW CHALLENGES ON ITS PLATE. TO ACCOMPLISH ITS TASKS, IT COMBINES FIVE TOOLS IN A UNIQUE SUITE OF INSTRUMENTS. On the surface of the red planet, it will point its infrared laser at target rocks to vaporize them at the impact point into a plasma. As this plasma recombines, it will emit visible and ultraviolet light that the LIBS laser spectrometer will analyse to determine their elemental chemical composition. Complementing this is the green laser of the Raman[1] spectrometer, which will illuminate rocks to get them to re-emit infrared light. The spectrometer will then identify minerals and detect any biomarkers. At a larger scale, an infrared spectrometer will analyse sunlight reflected on the surface or rocks to identify any minerals and organic compounds. A fourth instrument, an HD colour camera, will take pictures of rocks and minerals analysed. Lastly, a microphone will record the first Martian sounds and those of operating instruments.

1. Raman spectroscopy is a non-destructive method for observing and characterizing a material.

MSR



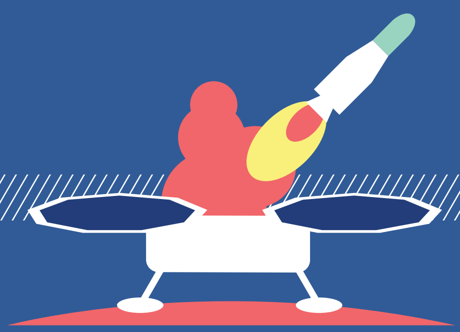
1. COLLECTING MATERIALS

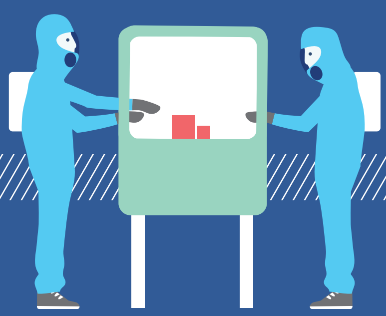
Launched in the summer of 2020 with the Mars 2020 mission, the Perseverance rover is set to land on the red planet in February 2021 near Jezero Crater, a site chosen for its ancient sediment layers. Perseverance's robotic arm will drill down as deep as six centimetres within a radius of several kilometres to extract samples of 15 grams of material, which will then be sealed inside tubes and cached. Traversing its landing site, the rover will leave 30 samples on the surface, grouped for easy retrieval.

2. RETRIEVING SAMPLES

All launched in 2026, the European Earth Return Orbiter (ERO) will go into Mars orbit in 2027 while the Mars Ascent Vehicle (MAV) and Sample Fetch Rover (SFR) will land in 2028. Designed to accommodate the contingency of Perseverance not making it to the rendezvous point, the SFR will retrieve the samples left on the surface. The samples will be placed inside the Orbiting Sample (OS) container under the MAV's fairing in readiness for the first ever launch from Mars. The ERO will then rendezvous with the OS in Mars orbit and capture it.

ANALYSING SOIL FROM MARS BACK HERE ON EARTH WILL SOON BE A REALITY WITH THE MARS SAMPLE RETURN (MSR) MISSION LED BY NASA AND ESA. REQUIRING THREE LAUNCHES FROM EARTH AND ONE FROM THE SURFACE OF MARS, TWO ROVERS AND A SAMPLE CAPSULE, THIS ENDEAVOUR POSES UNIQUELY COMPLEX ENGINEERING CHALLENGES.





3. **DELIVERING** THE CAPSULE

Once the OS is inside the Earth Entry Vehicle (EEV), the ERO will begin the return journey after jettisoning all unnecessary mass. As it approaches Earth, and after checking that everything is under control, it will release the EEV capsule on a re-entry trajectory before changing course to avoid the planet. With its heatshield and shock absorbers to protect the OS, the capsule will crash into the Utah desert in 2031 with its 500 grams of Mars samples.

4. **ANALYSING** SAMPLES SAFELY

To avoid all risk of contaminating Earth's environment with possible Martian organisms, the samples will be stored inside three sealed containers like Russian nested dolls until their arrival on Earth. They will then be picked up in Utah by an armoured truck and taken to a P4 facility. The samples will only be released for closer analysis in other laboratories once they have been confirmed as harmless.

AMÉLIE LUCAS-GARY

Author

"For a writer, space is the absolute of fiction and dreams..."

Amélie Lucas-Gary has a fertile imagination and excels in the art of opening up new possibilities. **In 2014, she published *Grotte*, the story of the guardian of a forsaken prehistoric cave visited by an asymmetrically shaped alien.** "For me, there's a strong link between the distant past, where we come from, and the vastness of space we so long to discover," says the author. "It's these inaccessible realms the imagination seems so well suited to explore. And from a spiritual and metaphysical perspective, space is such a source of inspiration." **To fuel her imagination, she devours a vast array of reading material, including the space press.** "I'm not a big fan of encyclopedias, it's more through stories, characters and structures that science inspires me," she says. She's now writing her third novel, *Hic*, which takes her back through time from home to the Big Bang, before returning to the present—in New Zealand. Naturally curious, Amélie Lucas-Gary enjoys "disrupting genres by mixing languages and registers". Her fresh style has impressed many, not least the Observatoire de l'Espace, CNES's art and science laboratory. In 2019, it commissioned her to write a piece for issue 18 of *Espace(s)* magazine in which she was asked to invent a way of decoding mysterious alien signals picked up by the Very Large Array Observatory in New Mexico. In *Discours de Mountain View* she offers a poignant reflection, where—free of any material questions—she no longer describes flesh-and-blood beings, but pure spirits. A quest she's now pursuing with her new novel, *Mars Mars*. **"I have to keep reminding myself that it's impossible to prove something doesn't exist. This leads to some spectacular prospects, like imagining the existence of lifeforms elsewhere other than our own."** In conclusion, "it's this freedom that space exploration offers to fiction!"

GABRIEL PONT

Head of CNES MSL and Mars 2020 Control Centres

"Every day, Curiosity is programmed with its tasks for the next day..."

The Mars exploration rovers are marvels of technology, but they aren't clever enough to make decisions on where to go and what to do. So, humans like Gabriel Pont program them from control centres on Earth. After the excitement of deploying the SEIS seismometer, which he was responsible for developing, Gabriel was keen to keep working on Mars missions. As subject matter expert on exploration aspects of the Martian Moons eXploration (MMX) mission, **he is today supervising the team of specialists at the French Operations Centre for Science and Exploration (FOCSE) working with ChemCam and SAM, the French instruments on the famous Curiosity vehicle.** "The rover is driven by NASA and travels a few metres a day in search of clues, especially in rocks, that might tell us more about the planet's past," he explains. **The route depends on the target, and the CNES engineers work with two scientists in the control room.** "If they think ChemCam has found an object of interest, they tell the rover to go in closer so it can make more accurate contact measurements, or even take samples and place them in the SAM analyser," says Gabriel Pont. "If not, they choose another target." Once the French telecommand plans are finalized, there's a series of videoconferences. These take place in California time, which is from 4 p.m. in France. "The team in charge of each instrument discusses its latest findings and any issues it has with the plan for the next day. It's important to check compatibility: ChemCam mustn't fire its laser at the rover's arm deployed to drill into a rock!" **After these talks, each team rewrites its plan, then NASA uplinks a single set of instructions, which Curiosity receives 7 to 30 minutes later.** That's the daily routine for Gabriel Pont's team, who'll soon be in charge of SuperCam, ChemCam's cousin, which launches on Mars 2020 in July.

SYLVESTRE MAURICE

Astrophysicist at the IRAP astrophysics and planetology research institute

"Nothing in our solar system is like Earth..."

Saturn, Jupiter, Mercury, Mars, the Moon—Sylvestre Maurice says searching for H_2O and habitability in the solar system makes you a kind of "planetary water diviner". "I travel the solar system thanks to the space agencies flying our instruments on their satellites and probes," he says. At IRAP's space instrumentation laboratory, overseen by Paul Sabatier University in Toulouse, CNRS and CNES, **his team developed ChemCam, operating on Curiosity since 2012, and SuperCam, which leaves for Mars on the Perseverance rover this summer.** "ChemCam has been 20 years of my life," he adds. "The most impressive of its many discoveries was that Mars was habitable in the past." But was it ever inhabited? This is the focus of the Mars 2020 mission: look for traces of life, wherever possible in situ, otherwise in samples brought back to Earth. To this end, **SuperCam will be tasked with selecting samples and characterizing their surrounding environment.** "Working closely with CNES, French space laboratories have a unique set of expertise that we continue to develop over time. With SuperCam, the team has achieved a real feat of technology. It's the same size and weight as ChemCam, but instead of two it comprises five instruments. As well as laser analysis of chemical composition and the imager, now in colour, it adds an audio microphone and two types of spectrometer to determine the molecular composition and architecture of rocks." **If Mars 2020 or the samples subsequently returned reveal traces of life, "it would mean that life emerged in two separate places in the same solar system and, consequently, that life could be everywhere in the Universe,"** he concludes. Of course, future missions will largely depend on these findings, with the focus shifting from robotic to more human exploration!

Jacques Arnould,
science historian
and theologian,
CNES ethics officer.

JACQUES **ARNOULD**

"YOU'RE NOT ALONE!"

Long thought impossible or even out of bounds, space travel today opens up the prospect of discovering and encountering extraterrestrial lifeforms. But are we ready for it?

Asked why he wanted to climb Everest, George Mallory replied: "Because it's there!" This famous quote from the British mountaineer is the leitmotif for everyone advocating space exploration today: it seems as obvious as the imposing presence of the Himalayan summit. In practice, the reasons for launching human or robotic missions into the cosmos that surrounds us are many and varied. Mallory's argument notwithstanding, one reason at least is the search for our origins, the origins of life. We have good reasons to believe that the search for extraterrestrial lifeforms, present or past, is helping to significantly advance our knowledge of the processes that led to the emergence and evolution of life on our planet and, more hypothetically, its future.

IN SEARCH OF THE 'OTHER'

The advent and advancement of astrobiology is a key development in the history of modern science. Drawing on diverse physical and biological disciplines has enabled great strides in the search for potentially habitable or even inhabited planets, as well as advances in our knowledge of lifeforms on our own planet—sometimes in the most unlikely places. Exploring space is already giving us a better understanding of ourselves.In so doing, we have, in a way, subverted the familiar cry of the sentry guard: "Who goes there?" We're no longer waiting for the 'other' to appear at our door—some hypothetical manifestation of friendly or hostile visitors from the heavens. With the coming of the space age, we've taken the initiative to venture beyond the ancient limits of our atmosphere and those marked out by the Moon. Our spacecraft and we ourselves have become 'extraterrestrial' in an attempt to discover and encounter those we already deem to be such. This role reversal isn't without consequence.
Today, as in the past, we're wary of anyone who crosses the borders and successive lines of defence around our collective and individual existences.
And we must also take responsibility for any actions we take beyond those borders. Could we be endangering the existences to whom we might one day announce: "You're not alone"?
We mustn't put off asking this question: it's already a matter of conscience and part of our responsibility as humans.

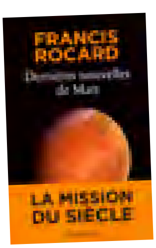
GOOD READS

Mars in all its wavy detail

In this book, Xavier Barral and Sébastien Girard present a series of 200 images captured by the HiRise telescope on America's Mars Reconnaissance Orbiter. The black-and-white rendering really brings out the relief of the Valles Marineris canyons, the Noachis Terra dunes and the Olympus Mons volcano. Readers also enjoy commentary by enlightened guides. Alfred McEwen, Principal Investigator of the HiRise camera at NASA, and Francis Rocard, astrophysicist attached to CNES, explain the planet's origins and evolution.

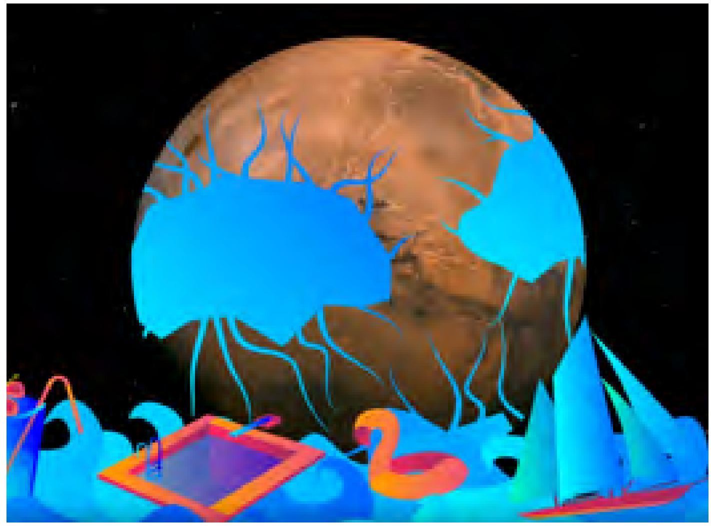
This is Mars,
by Francis Rocard, Alfred S. McEwen, Xavier Barral and Sébastien Girard – Published by Barral.

Mars: mission of the century



From 3 June 2020, you can relive the entire Mars adventure. Why and how are scientists taking such an interest in Mars? Despite similarities, why hasn't the red planet evolved like Earth? In his latest book, Francis Rocard tells the story of how humans will travel to Mars in the next two or three decades. The astrophysicist in charge of solar system exploration programmes at CNES describes chapter by chapter the stages that will eventually enable crews to fly to and land on Mars.

Dernières nouvelles de Mars,
by Francis Rocard – Published by Flammarion.



EDUCATION

ON HOLIDAY **IN THE SOLAR SYSTEM**

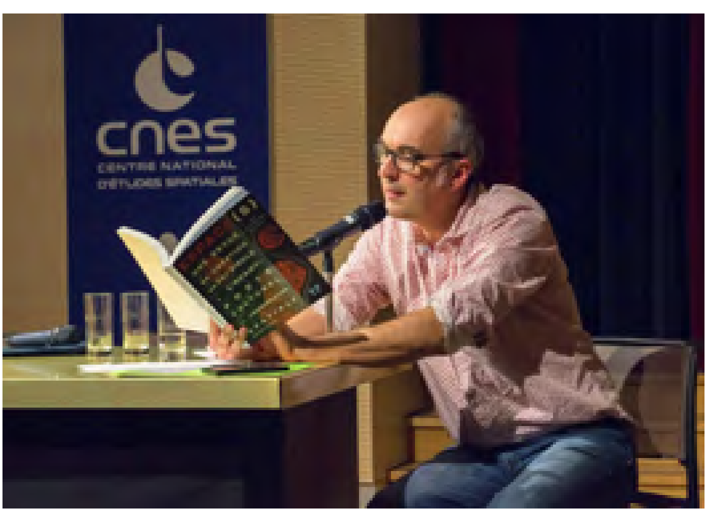
What are you doing for the holidays? CNES's Youth department is offering a fun-packed tour of the planets, complete with a Mars safari, a bit of Moon therapy, a cruise to the Sun and even a trip to the comets. Bring the kids, because the agency has created the "*En vacances dans le Système Solaire*" (On holiday in the solar system) series just for them, with eight episodes available online. This fun educational concept is aimed at children from fourth grade to senior high school. Each sequence runs for three or four minutes and stars a couple embarking on a voyage of discovery to the planets, comets and other asteroids. The form may be light-hearted, but the content is rigorously researched. The two virtual 'tourist' characters explain space with the aid of real ESA and NASA satellite images. Designed to spark interest in space, the series has been welcomed by teachers and educators. The videos also give parents a simple and engaging resource based on solid, reliable knowledge for enquiring minds of all ages. CNES works closely with schools, activity centres and clubs. It also operates a dedicated youth website and produces educational media aimed at youngsters. The video series is designed to supplement these existing resources.

CHECK OUT "*EN VACANCES DANS LE SYSTÈME SOLAIRE*" **ON CNES'S YOUTUBE CHANNEL (IN FRENCH).**

ÉRIC PESSAN

AUTHOR IN SPACE RESIDENCE

Beyond Earth, hospitable planets are few and far between. Yet there is one–and Éric Pessan has set up his writing workshop there. The author is currently in residence at the Observatoire de l'Espace, CNES's cultural laboratory, where he's putting the finishing touches to a fictional novel, which he wants to be "as close as possible to the realities of space".
Talks with experts feed into his story, but Éric Pessan was already familiar with the space sector. First contact came when the Observatoire asked him to write some articles for *Espace(s)* magazine. He found that space "really fires the imagination". Since then, his collaboration with *Espace(s)* has shifted up a gear. To get a genuine feel for space, he even braved a parabolic flight in 2013. His residency at the Observatoire, under the umbrella of the Île-de-France regional council, is a logical next step. During his time, he's also holding writing workshops for high school students and sharing his thoughts with them. And as usual, Éric Pessan will be turning all these meaningful interactions to advantage.



DIARY

NEXT DEPARTURES FOR MARS
14 July 2020 (at the earliest):
Hope on an HII-A launcher (Japan)
Summer 2020:
Mars 2020 with Perseverance on an Atlas 541 (Cape Canaveral, USA)
August 2020:
Tianwen-1 on a Long March 5 (China)

NEXT ARRIVALS ON MARS
February 2021:
Perseverance lands at the Jezero Crater site
February 2021:
Hope enters Mars orbit
April 2021:
Tianwen-1 lands at the Chryse Planitia site

CHEOPS
A slice of art in space

The CHEOPS mission serves two objectives: one scientific, the other educational and cultural.
The result of an EU/Swiss collaboration, the programme also included a competition for children in the 22 ESA member states, who were invited to draw their perceptions of the Universe.
The idea is to inspire young people to choose careers in science.
Some 2,748 pictures were chosen by lot. They were then reduced by a factor of 1,000, etched onto two titanium plaques at Bern University of Applied Sciences and placed on the CHEOPS exoplanet satellite for an exhibition... in space!

LEARN MORE:
EARTHLINGS, LEARN MORE ABOUT THE EXHIBITION AT HTTPS://CHEOPS.UNIBE.CH

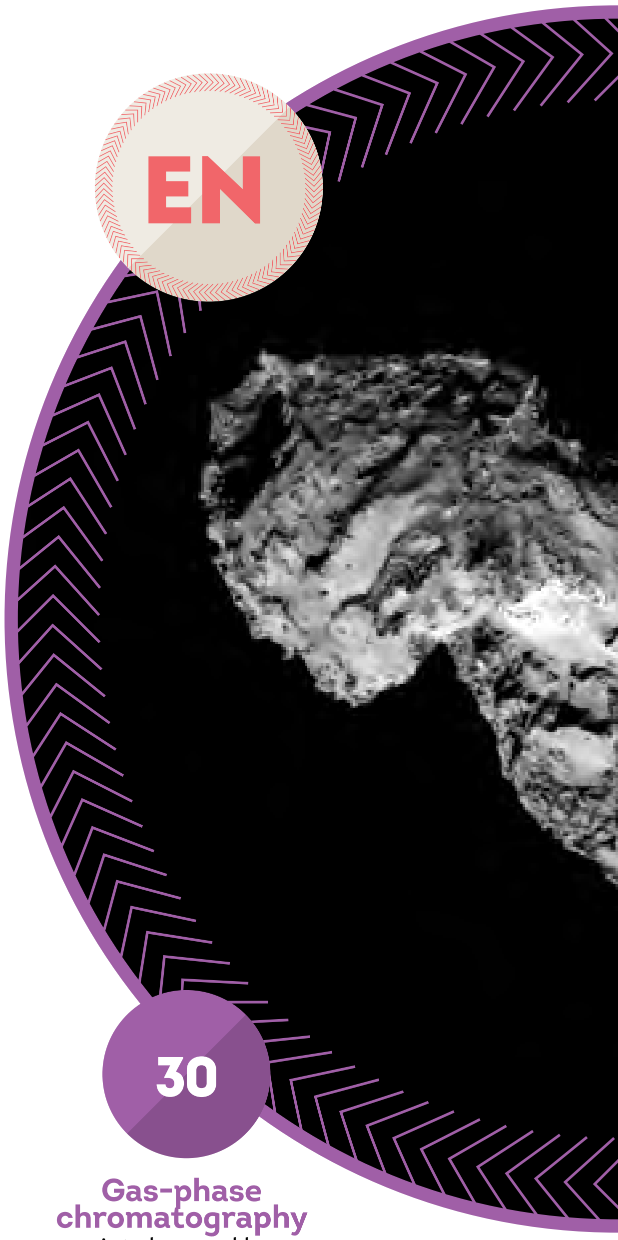
THE SCENTS OF LIFE

Perfumers in the world's perfume capital Grasse unexpectedly share something with fundamental space research: both use gas-phase chromatography. In 2004, Rosetta was already carrying a chromatograph and now it is ExoMars' turn.

How did the first molecules synthesize to create life? Uwe Meierhenrich, the director of the Nice Chemistry Institute, has devoted his entire career to cracking this conundrum. "We're trying to understand how biological molecules evolved to work our way back in time," he explains. "To do that, we look for key molecules like amino acids, which form proteins and enzymes, and simple sugars that are the building blocks of genetic material." Chromatography can identify such 'basic' molecules when elements are in a gaseous state, but they are too common on Earth to be able to distinguish those that were really involved in the emergence of life. And that's where experimenting in space comes into its own. Rosetta's not very powerful chromatograph only revealed a single amino acid on Comet Chury, but as early as 2004 Uwe Meierhenrich discovered no fewer than 16 in the 100 milligrams of man-made comet created by his research group in the lab.

DESCRIBING MARTIAN CHIRALITY

Some chromatographs can now identify chiral molecules which, like our hands, exist in left-handed and right-handed forms (see Roundup p. 8). "Surprisingly, we found that chiral amino acids in living organisms are all left-handed! To gain a deeper understanding of what role they played in sparking life on Earth, the European ExoMars mission will be carrying a chiral gas-phase chromatograph in 2022," enthuses Meierhenrich. So will amino acids on Mars be left-handed, right-handed or neutral? In the meantime, "thanks to our technology the perfume industry is reinventing itself, as odorous chiral molecules do not have the same scent according to whether they are left-handed or right-handed," says the research scientist with a smile.



Gas-phase chromatography is today capable of detecting more than 30 chiral amino acids in comets created in the laboratory.

Comet Churyumov-Gerasimenko pictured by Rosetta.