ETH Zürich Foundation

Uplift

The impact of giving

Nº15

When rocks give rise to life
NOMIS Fellow Craig Walton

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Funding focus

Origin of life

ETH Foundation

Examining life from all sides

Image supplied

Didier Queloz
Nobel laureate, Professor of Exoplanets at ETH Zurich, Director Centre for Origin and Prevalence of Life

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EDITORIAL

In 1995, in collaboration with my PhD supervisor Michel Mayor, I succeeded in discovering the first planet orbiting a star other than the Sun. It was to take years until the scientific community accepted our findings and grasped their implications. This began a series of advances that led to the discovery of many other extrasolar planets and spurred on the search for life beyond Earth.

I'm convinced that there's life in the universe. The only question is whether we'll ever find it. To this end, ETH Zurich set up a new research and teaching centre in 2022. Named the "Centre for Origin and Prevalence of Life", it consists of over forty research groups from seven departments. This diversity is required, as the question of the origin of life – resembling a huge puzzle – needs a multi-perspective approach and research culture. Read on to find out more about some of the younger researchers working on our mission and join us on one of the most exciting journeys of all – the journey to where life begins!

The rocky road to the beginning

Craig Walton's quest is to find out which conditions on Earth gave rise to life. Thanks to a NOMIS fellowship, he can draw on the unique expertise available at ETH's Centre for Origin and Prevalence of Life.

The basic idea behind Craig Walton's research sounds fathomable: "If we can reproduce the geological conditions prevailing on Earth before life began, we'll be able to find out how life originated and how it was able to continue," the earth scientist explains. "To explore this possibility, I want to build miniature planetary landscapes inside glass jars." But what exactly were these conditions and where do the ingredients needed to recreate them come from? "Findings from Earth and planetary science research deliver important information about the environment that existed on Earth over four billion of years ago. By working closely with researchers from other disciplines who are also investigating the origin of life, we can add more parts to the puzzle," the scientist continues. To implement his idea – a highly complex undertaking – Craig Walton has access to the interdisciplinary network of the Centre for Origin and Prevalence of Life (COPL) at ETH Zurich. "At the Centre we can pool knowledge and hopefully answer questions together," he says excitedly.

Scottish volcanoes and Pokémon

Craig Walton's interest in geology started young, having grown up in Scotland, near Edinburgh and the famous mountain of volcanic origin, Arthur's Seat. Scotland's rugged landscape – which has played an important role in many significant geological discoveries – was one factor that spurred the researcher's passion for earth sciences. However, the second reason for choosing the field is more surprising. "It was Pokémon," Craig Walton acknowledges with a laugh. "The earlier games often involved rocks and the way in which life and geology are connected. This idea echoes throughout my research."

The fact that he's now conducting this research in the group led by ETH Professor Maria Schönbächler at the Institute of Geochemistry and Petrology is thanks to the partnership between the NOMIS Foundation and ETH. After completing his doctorate and working as a researcher at the University of Cambridge, he applied for the three- to four-year NOMIS-ETH fellowship and was accepted. "The fellowship gives me the freedom to explore ideas I've been thinking about for ten years. This chance to take risks and chase a vision is incredibly valuable," Craig Walton enthuses.

Cosmic dust: a free lunch for early life?

He's convinced that COPL is the perfect place for his research. "The resources and expertise here are unique. Whether material

Meteorite splinters provide Craig Walton with important clues about the environment on Earth over four billion years ago – like from the Bencubbin meteorite in the collection of the Natural History Museum in Vienna, a metal-rich carbonaceous chondrite and one of the oldest rock materials in the solar system (see following page).

sciences or information technology, findings from many fields are relevant when it comes to the search for the origin of life." In Maria Schönbächler's lab, he can study crucial samples: micrometeorites and cosmic dust that she was able to bring back from an expedition in Antarctica. Based on his research, Craig Walton suspects these powdery extraterrestrial materials played a role in the formation of life. "Cosmic dust is everywhere – there will be some on the roof of your house, right now! It probably accumulated in certain places on early Earth. Crucially, cosmic dust is made up of the elements needed by life and, due to its unstable chemical form, may have easily broken down, offering something of a 'free lunch' for first life," the researcher explains. However, a free lunch alone isn't enough to get life going.

"I'm not only interested in how the chemistry of life first started, but also in how it was able to continue. My guess is that only a few environments could have supported the large appetite of emerging life. Life would then have had to quickly learn to be efficient with the resources available, as early stocks of easily accessed 'food' started to run out. In other words, it learned how to recycle!" the geologist continues. "Microbes figured out how best to use limited resources billions of years ago – perhaps human civilisations should follow their example."

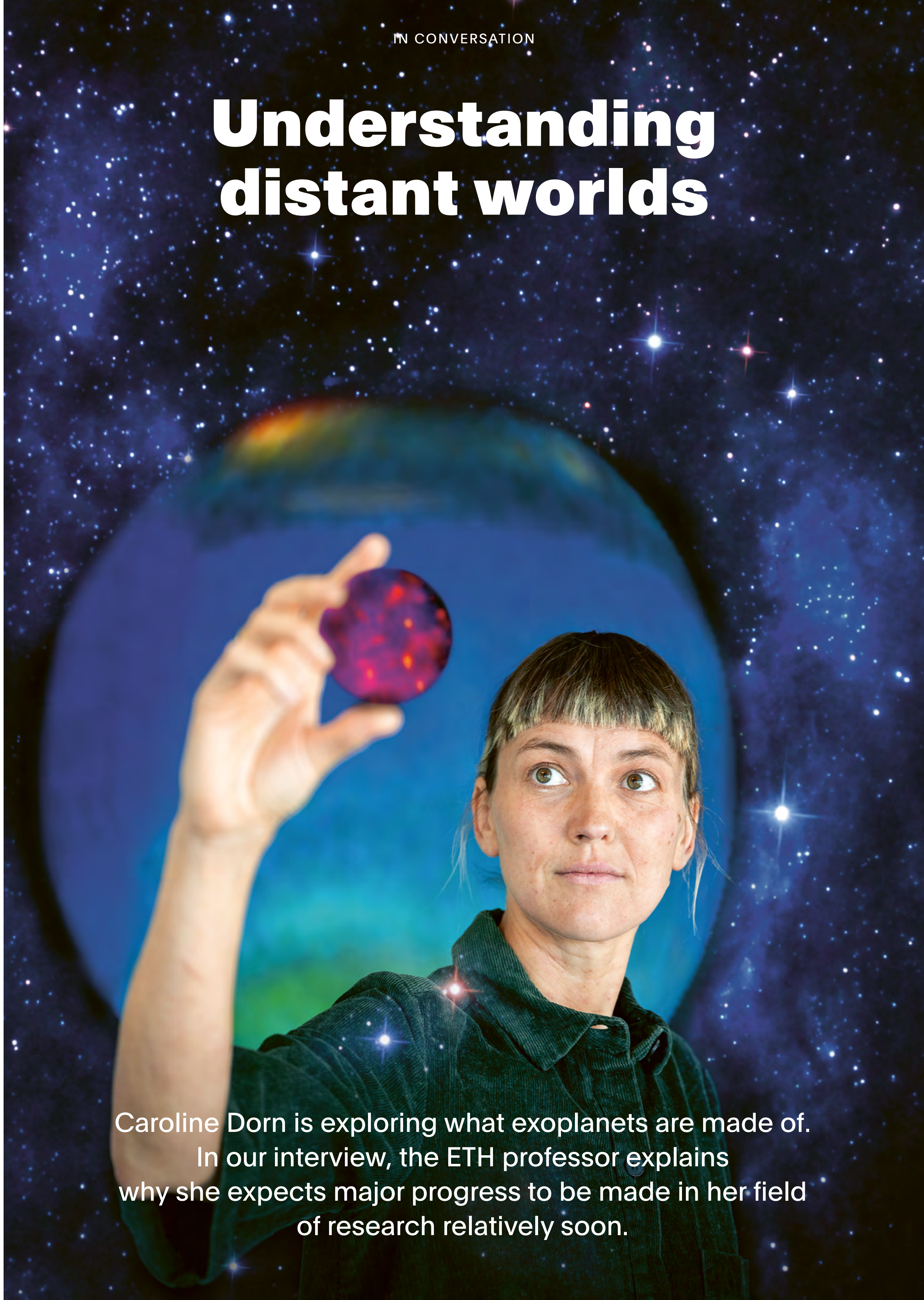
As far as expectations go, the researcher remains realistic. "The goal is not to solve the puzzle of life in the next four years," he laughs, "but hopefully we'll uncover something new and exciting!" However, any new insights about Earth will also provide clues to the question of life on other planets. Craig Walton doesn't rule out the possibility that life exists – or has existed – in the far reaches of outer space. However, he also thinks it's conceivable that the particular history of life on Earth is unique. "I think the chance that we'll find intelligent life is small. Aliens might indeed be green; but look like microbes, rather than humans!"

Find out more:
ethz-foundation.ch/en/origin-of-life

NOMIS – ETH Fellowship Programme

The NOMIS Foundation – ETH Fellowship Programme gives early-career researchers the opportunity to explore the origin of life, take risks and build bridges across disciplines – all in a unique environment. The fellowships are hosted by the Centre for Origin and Prevalence of Life at ETH Zurich.

More about the programme



Understanding distant worlds

Caroline Dorn is exploring what exoplanets are made of. In our interview, the ETH professor explains why she expects major progress to be made in her field of research relatively soon.

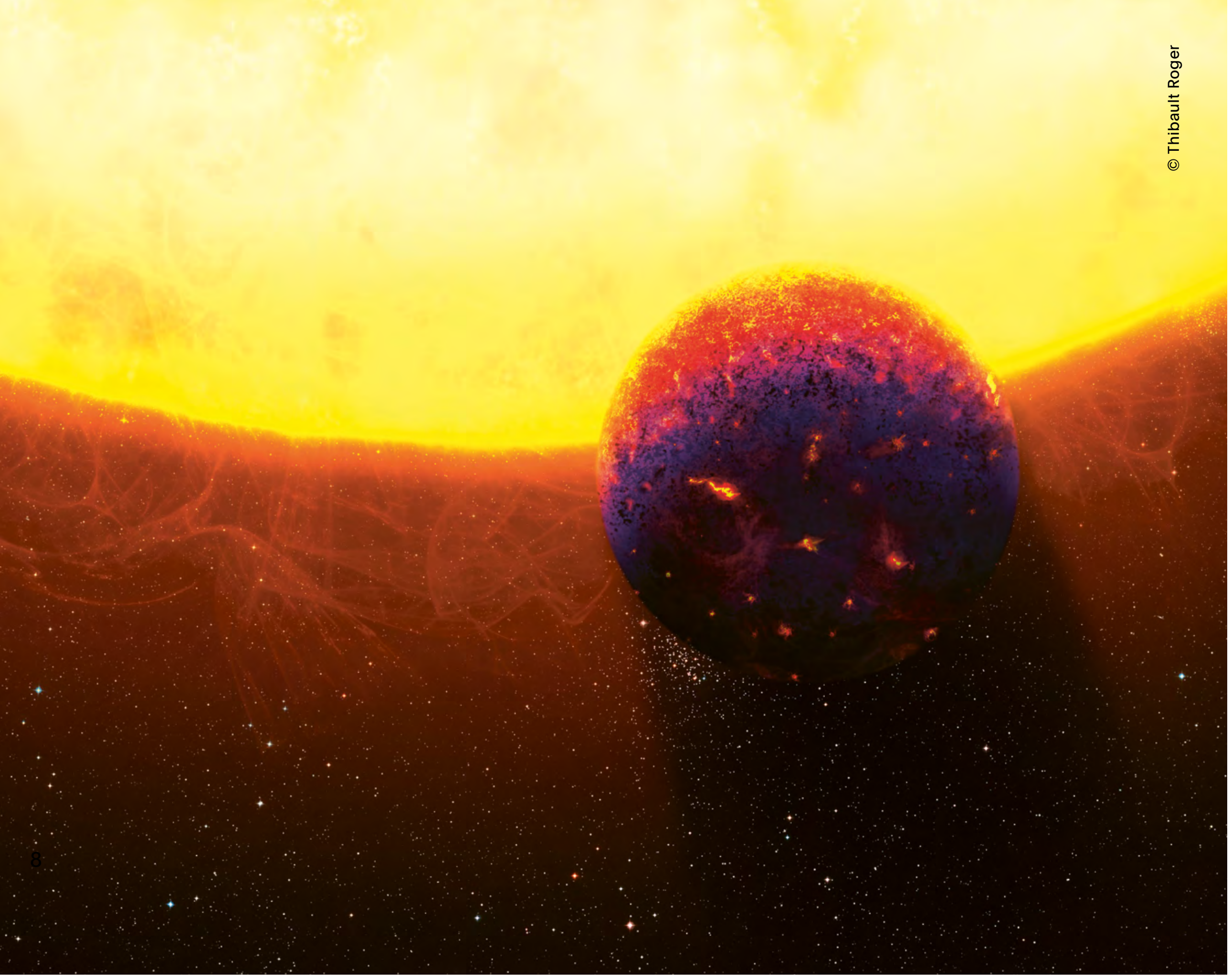


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Illustration of the super-Earth 55 Cnc e, which orbits its star so closely that its surface temperature is almost 3000 degrees. Caroline Dorn has shown that 55 Cnc e can shimmer reddish blue due to a possible large occurrence of sapphires and rubies.

You've been working on extrasolar planets, i.e. planets outside our solar system, for about ten years now, since this year as an ETH professor. What's your story?

CAROLINE DORN – Originally, I started off in earth sciences. This means that up to and including my doctorate, I devoted my attention to geophysical phenomena, like earthquakes and water in bedrock. When, in 2013, the University of Bern was looking for someone from the field of geophysics to research exoplanets, I applied and got the job. Exoplanet research is still very young. Once astronomers had realised that they could find extrasolar planets, there was suddenly great demand for expertise from all kinds of other fields. That's how my career took a change of direction and I came to this field. On the first day of my postdoc, I first had to look up the definition of "planet".

How does it benefit you today that you had a scientific career before getting involved in exoplanets?

I think it's done me good to get to know different disciplines and their particular scientific cultures. It's like being able to speak different languages. This is exactly what's needed if you want to work on an interdisciplinary basis. It's easy to talk about "interdisciplinarity", but to put it into practice, you have to take time and really immerse yourself in another discipline.

Speaking of interdisciplinarity – why does the Centre for Origin and Prevalence of Life at ETH place so much weight on this?

Exoplanet research – and research into the origin of life as a whole – is an ideal field for creating links between disciplines which, in turn, enables major advances to be made more quickly. We're lucky in that the Centre provides a unique environment for this dynamic field and great potential for making flying leaps in our findings.

What are you looking for in your research?

I want to find out what distant worlds are made of, as the composition of a planet tells us things about its origin and evolution. For example, I want to discover how much water can be found there, how big the iron core is or what the atmosphere is made of. Water is an important building block for life on planets, so I'm also interested in where and in what form it's found. Is it possible for oceans of liquid water to exist there long-term? To answer these questions, I work with existing data on the mass and size of planets. Our models also use information on how materials behave at high pressures and temperatures. In other words, I delve deep into the inner lives of exoplanets.

To date, over 5000 exoplanets of all different kinds have been identified. Where does your particular focus lie?

Of the planets we can see with today's technology – which represent only the tip of the iceberg – most are larger than Earth and smaller than Neptune. Known as super-Earths and mini-Neptunes, these are the ones I'm focussing on. They're particularly interesting because they don't feature in our solar system yet are very common in other systems. Does that indicate that our solar system is somehow special? I'd like to find out what super-Earths and mini-Neptunes are made of. In the past, the models used in exoplanet research were quite simple: we worked on the basis that different layers of gas and rock are separate from each other and chemically inactive. However, in the last five years we've realised that these worlds are much more complex: water and other gases are not completely separate from the rocky interior. In my research group, the aim is to build more complex models that connect a planet's atmosphere with its deep interior. In our work, Earth provides us with so much valuable information, as it's by far the planet we know best. We can use the measurements taken here to check our models. This makes Earth both a benchmark and a source of inspiration.

Our great interest in exoplanets is related to the fact that we humans would like to know if there's life elsewhere in the universe. Tell us what you see in the crystal ball!

I'm sure we'll find life on other planets – at least indicators of a biosphere. I could imagine, for example, that we'll find a gas composition whose imbalance must be of biological origin. Or that we'll discover in the spectrum of an exoplanet back radiation that's typical for plant life. However, I rule out the possibility of us ever travelling to exoplanets. With today's technology, it would take 100,000 years to reach the next exoplanet. So, you could say that if we're never going to set foot on an exoplanet, who cares? But just the thought that I may one day be able to point to something and say to my children, "there's probably life there!" is so fascinating that this is more than enough incentive.

Solving the mystery of life

Founded in 2022, the Centre for Origin and Prevalence of Life (COPL) comprises researchers from more than 40 groups across a wide range of disciplines, including biology, chemistry, earth sciences, astrophysics and environmental systems sciences. Guided by a shared scientific vision, they study the chemical and physical processes that have enabled the emergence of life, as well as the planets and environmental conditions that allow it to prosper and evolve. Under the leadership of Nobel Laureate Didier Queloz, the centre thrives on flexible and synergy-based forms of cross-disciplinary collaboration. A selection of the researchers and their questions:

Paolo Sossi
From which minerals, liquids and gases are other planets formed?
The experimental planetologist simulates in his lab the conditions in the atmospheres and on the surfaces of planets and what makes up their core.

Tanja Stadler
How does life develop?
Genetic information changes during reproduction, branching out like the boughs of a tree. The biostatistician reconstructs the tree from genetic sequences and then calculates the biological processes. The method works for viruses as well as for ecosystems and different time scales.

Cara Magnabosco
What happens when life enters an uninhabited world?
Conducting research on the interaction between living and non-living systems, the earth scientist is fascinated most by life deep underground, i.e. organisms that "breathe" rocks rather than oxygen.

Loïc Pellissier
How do landscapes change in relation to biodiversity?
One line of research the ecosystem scientist follows is the complex way in which biosphere, climate and topography have co-evolved since life began.

Marco Stampanoni
How can we develop novel X-ray based instruments and methods to investigate biological samples non-invasively?
The professorship is part of the Institute for Biomedical Engineering at UZH and ETH and is dedicated to developing new methods in connection with the synchrotron light source at the Paul Scherrer Institute PSI.

Derek Vance
How has the Earth's surface evolved over the course of its history?
Using isotopic and geochemical tracers to study global cycles, the geochemist investigates sediments and rocks to apply his findings to the Earth's past.

Sascha Quanz
Is there life beyond the solar system?
The astrophysicist leads the international LIFE initiative, which is developing an ambitious space mission to search for trace gases of life, such as oxygen or methane, in the atmospheres of Earth-like exoplanets.

Roland Riek
Which building blocks enabling the emergence of life came first?
The researcher in the field of physical chemistry assumes that the first chemical world, appearing a few hundred million years after Earth came into being, consisted of amino acids and self-replicating small proteins formed from these acids by volcanic gas.

Julia Vorholt
How does the complexity of life evolve?
The microbiologist is interested in bacteria and archaea, the groups of organisms that emerged back in the first half of our Earth's history. She studies their metabolism and how their interactions contribute to the complexity of life.

Helma Wennemers
How did metabolism in the prebiotic world emerge?
In her efforts to learn more about the role that peptides play in the emergence of life, the organic chemist develops catalytically active peptides and supramolecular materials.

Unlocking potential

By supporting the next generation of peace mediators at ETH Zurich, Dorothy and John Nagulendran want to show how private philanthropy can make a difference in addressing global challenges.

You both grew up in Singapore. What brought you to Switzerland?

DOROTHY NAGULENDRAN – John and I first met 25 years ago during our undergraduate studies at King's College London. John was studying law, while I was doing a music degree. Following our graduation, we returned home to Singapore to work and got married. Over the last 20 years, we've moved a lot, living and working in Shanghai, Jakarta, and London, before relocating to Zug about 13 years ago.

JOHN NAGULENDRAN – Our family moved to Switzerland in 2010 when I accepted a new role at Pala Investments, an international private equity firm based in Zug. When we first arrived, it was just Dorothy, our one-year-old daughter Martha, and I. Today, we're a family of six, with the addition of our two other daughters, Gemma and Lucy, and our puppy dog, Milo. Switzerland is our adopted home country. We're thankful and feel very at home.

Your support enables the award of the peace mediation scholarships to two young women professionals in the MAS ETH Mediation in Peace Processes programme. How did this come about?

J.N. – As is common amongst many of us in our workplaces today, I experienced burnout last year after a career of 22 years. I took this opportunity to pause and reflect on ways to channel my energy to help make a positive impact. As I'm deeply interested in problem-solving, negotiation and mediation, I came across the MAS at ETH and was curious to learn more. Through conversations with Eemeli Isoaho, the programme coordinator, and Professor Andreas Wenger, the programme director, I was inspired by their passion for training the next generation of peace mediators. This encouraged Dorothy and me to set up the 10-year scholarship fund to support young peace mediators. In a world where conflict and political violence are destroying livelihoods, separating families and resulting in human suffering, we hope that through the scholarship fund, we can support ETH's mission to professionalise the peace mediation sector.

What was it about the programme that impressed you and John?

D.N. – Switzerland has a long tradition of supporting peace mediation. Thanks to the close partnerships ETH has with national and international institutions, the MAS is able to offer best-in-class trainers with vast experience in the world of peace mediation. Additionally, the multi-disciplinary programme incorporates extensive practitioner

orientation to equip participants with the knowledge, skills and techniques to effectively mediate violent political conflicts. Finally, we were also impressed by the diverse participation, with 59 students from 36 countries having graduated from the programme since its launch in 2017.

Why are the scholarships targeted at women peace mediators from Asia?
J.N. – Since the MAS was launched, it has had three cohorts of graduates. One key feedback from past participants to improve the programme was to incorporate more diversity in terms of trainers and mediation approaches. This included suggestions to incorporate both Asian and gender perspectives of mediation into the programme. Coming from Singapore and a family of four women, we felt that establishing the scholarship fund for women from Asia would address this feedback in a meaningful way.

Two scholarship holders will soon be starting the programme. What impressions do you have of the profile of the scholars?
D.N. – Very positive! The two scholars are highly qualified and experienced in their fields. One of the scholars is from the Philippines and has been working at the Centre for Humanitarian Dialogue in Geneva for over seven years supporting the peace process in her country. The second scholar is from Colombia and works at Dialogue Advisory Group, an independent organisation which facilitates political dialogue between governments, armed groups and other key actors in conflict situations.

As part of your support for ETH, you've founded your own philanthropic fund. What are your priorities?
J.N. – The Nagulendran Philanthropy Alliance is a Swiss-based philanthropic fund. We want to focus on capacity building to support peace and humanitarian projects, sustainability and climate action as well as diversity and inclusion initiatives. Our goal is to support projects where we can make a positive impact and address global challenges. We're working with partners to identify and establish such projects which can offer beneficiaries a platform for creativity, growth and empowerment.

What do you hope your funding will achieve?
J.N. – We want more people to recognise the value of private philanthropy. We don't have to be Bill Gates to play a role. Everyone can help others by giving their time, energy and ideas to make an impact. I hope that our contribution will not only raise greater awareness of the important work of peace mediators but also serve as a catalyst for others to come forward to support such an important cause.

Master of Advanced Studies ETH Mediation in Peace Processes

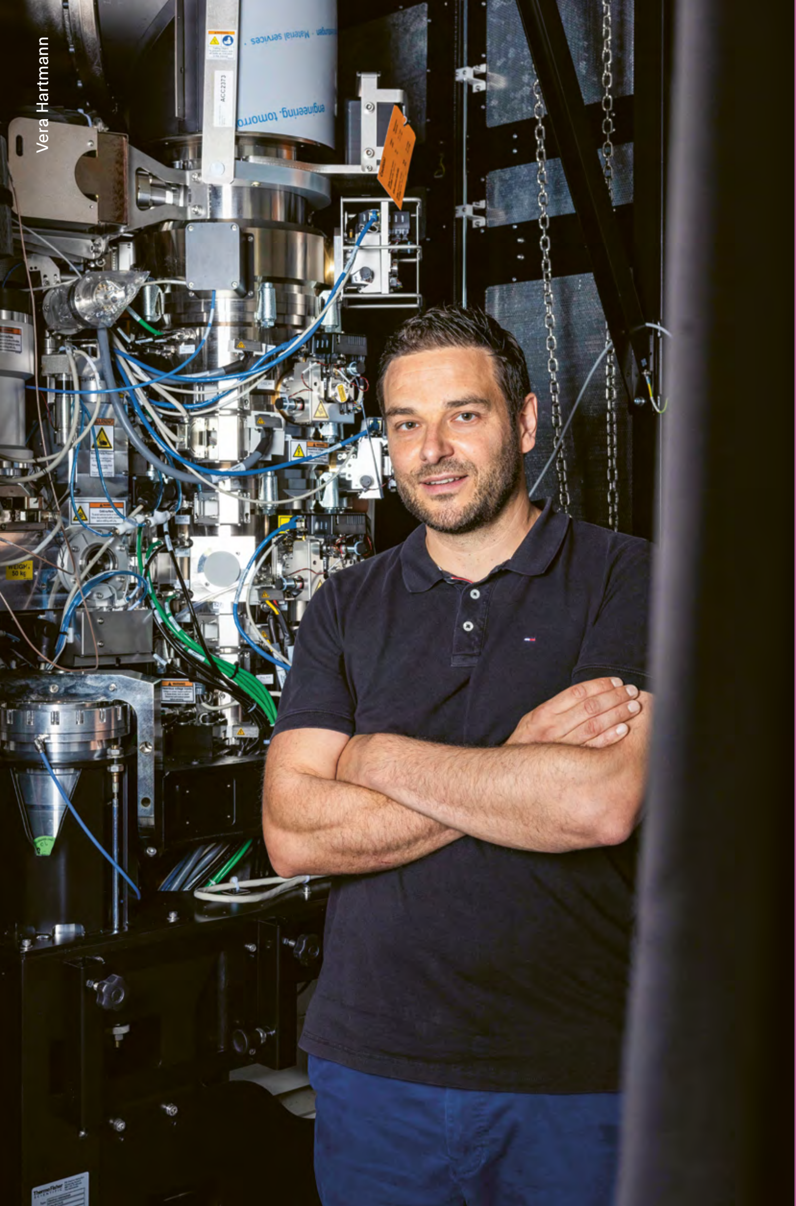
The MAS ETH MPP is a two-year course for professionals engaged in mediating violent political conflicts and supporting dialogue and peace processes across the world. It is based on a close partnership between ETH Zurich, the Federal Department of Foreign Affairs (FDFA), the United Nations (UN) and the foreign ministries of Germany and Finland.

More about the MAS:
mas-mediation.ethz.ch

Vera Hartmann

Deep insights

Martin Pilhofer's research helps us better understand how life on Earth emerged and evolved. His professorship was created with the support of partners.



Vera Hartmann

"By visualising the structures of intact cells, we gain new insights into key life processes and create the foundations for future medical applications."

Martin Pilhofer

The goal set by Martin Pilhofer and his team is to find out how microscopic living beings – so-called microbes – interact with other cells. He's particularly interested in investigating the structures that mediate these cell-cell interactions. By combining cryo-electron microscopy (cryo-EM) with other imaging techniques, the group can link findings ranging from the molecular to cellular and intercellular levels. This means that data sets from light microscopy provide information in the micrometre range, while methods from structural biology – which is where cryo-EM comes in – provide insights at atomic level in the nanometre range and below.

In cryo-EM, cell samples need to be prepared before they can be examined under the electron microscope. This is achieved with a process that stabilises the samples using a flash-freezing technique. Pilhofer made significant improvements to this technique during his research stay in the USA and, in 2014, brought it to ETH, where he was appointed assistant professor and then associate professor. As a result, another key aspect of the group's work, besides its research into various cell-cell interactions, is further developing cryo-EM.

How everything began

Martin Pilhofer's professorship is one of four in the Department of Biology affiliated with the Centre of Origin and Prevalence of Life. Its creation was made possible by donors that included the NOMIS Foundation; similarly, the team is able to work with the very latest cryo-EM equipment thanks to the Baugarten Stiftung and August von Finck family. In his research conducted within the context of the interdisciplinary centre, Pilhofer is studying the evolution of single-cell organisms. He says: "The further back we go in Earth's history, the more uncertain our hypotheses and findings become." Even the emergence of the first single-celled organisms cannot be precisely determined. Based on evidence provided by fossil bacteria, it's estimated that they appeared around 3.5 to 4 billion years ago. "We assume that in extreme places such as deep-sea vents or hot springs, the original single-celled organisms split into bacteria and archaea soon after their emergence," the microbiologist says.

Pilhofer and his group are now making high-resolution electron microscopy images of so-called Asgard archaea. The ETH researchers want to find out what the cell membrane of the Asgard archaea looks like and whether there's a special inner membrane system in these cells. "This research helps us to better understand how a host cell that fused with a bacterium then developed into a complex cell," Pilhofer says.

Interesting funding opportunities

Martin Pilhofer's research contributes important pieces to the puzzle of the origin of life. But many are still missing. For the Centre for Origin and Prevalence of Life to leverage its full potential, further financial backing from donors, foundations and industry is required. In the current phase, funds are particularly needed to provide early-career researchers with support – like fellowships for doctoral students, for example.

Find out more:
ethz-foundation.ch/en/origin-of-life

"Many research groups from different ETH departments have one thing in common: the great desire to understand the origins of life. By setting up the Centre for Origin and Prevalence of Life, we've created the best environment possible to transform this collective interest into collective answers."

ETH Zurich / Markus Bertschi

Joël Mesot, President of ETH Zurich, Vice Chair ETH Foundation Board of Trustees

Valeriano Di Domenico

Your support

For decades, researchers have been hunting for clues to solve the mystery of life on Earth and beyond. With milestones that include significant advances in chemistry, studies of rock samples from Mars and the discovery of Earth-like planets beyond our solar system, it's now the ideal time to join forces and seek answers to the big questions of life together. **You too can become part of this exciting research!**

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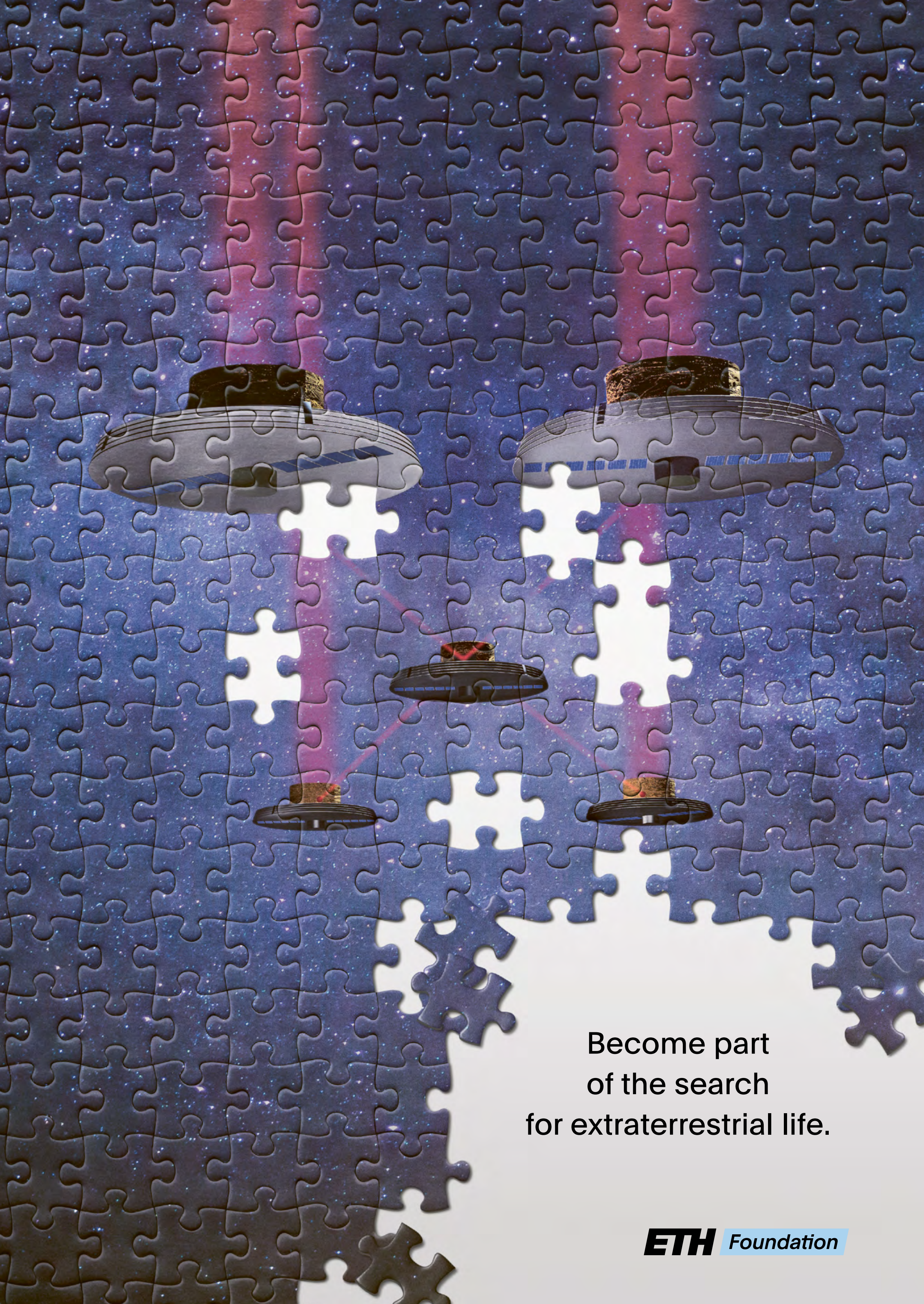
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