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Facts in the post-truth era

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Introduction by Prof. Robbert Dijkgraaf

The Eriskay Connection

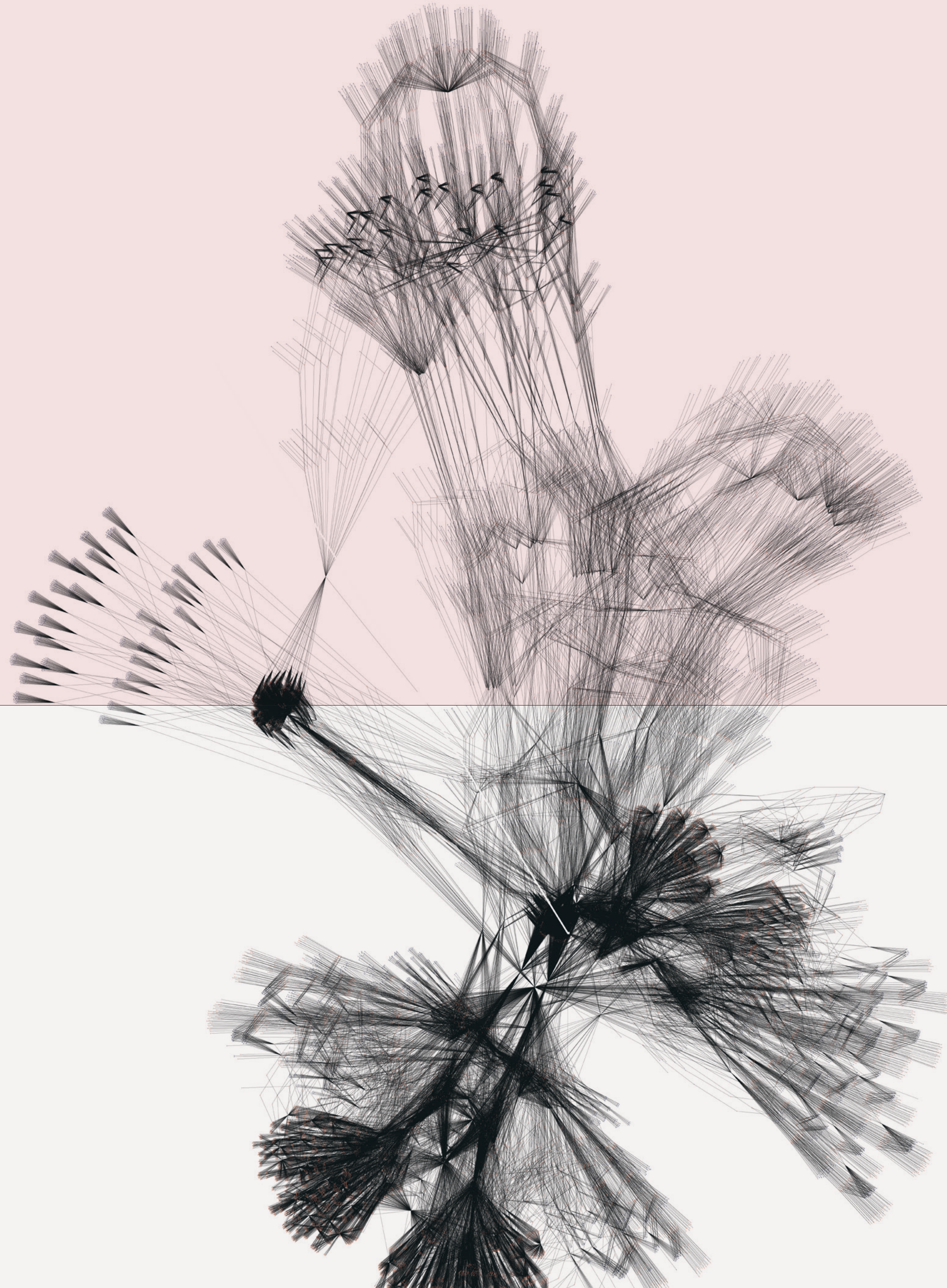
Professor Robbert Dijkgraaf

It is the best of times for science. Never before have there been so many discoveries and ideas, questions and challenges, and talent and technology. We are witnessing a transformation of society. One could characterise the science of the previous century as the search for the building blocks of reality. The molecules, atoms and elementary particles out of which all matter is made. The cells, proteins and genes that make life possible. The bits, algorithms and networks that form the basis of information and intelligence. This century will explore all there is to be made with these building blocks.

In 14 billion years of cosmic history and 4 billion years of life on Earth, nature has explored only the tiniest fraction of possible designs. This natural discovery process is now vastly accelerated in our laboratories and universities. With the help of new ideas, technologies and powerful, self-learning computers, we will map this new world of “artificial” materials, organisms, intelligence, and perhaps even better versions of ourselves. The impact on society of all that will be spectacular.

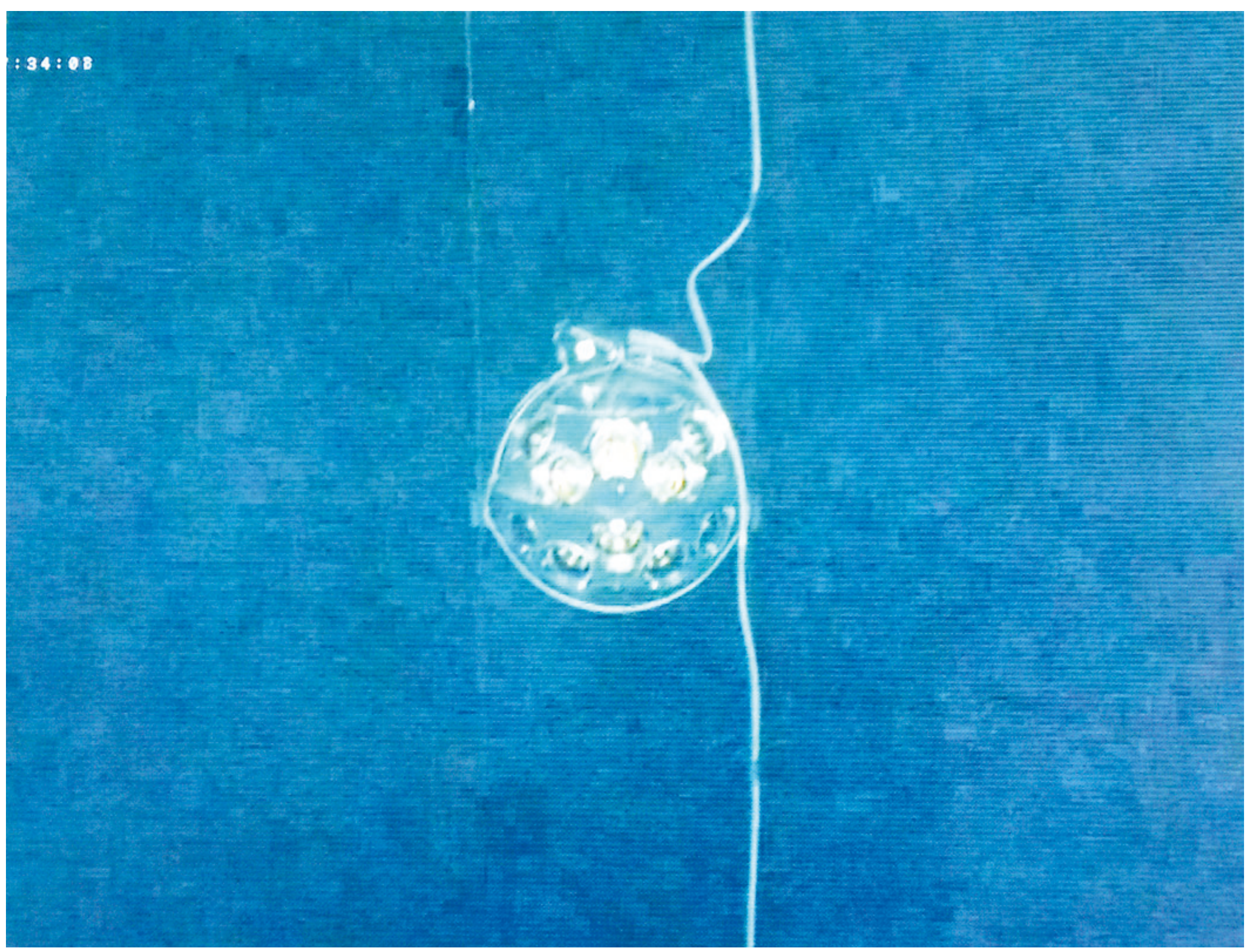
Curiosity-driven basic research is known to bring truly revolutionary transformations, as we have seen in the discovery of the genetic basis of life and medicine, the new nano materials and energy sources designed at the molecular level, and the rapid growth of computer-based intelligence. Einstein’s century-old theory of relativity is used every day in our GPS tracking devices. Quantum mechanics

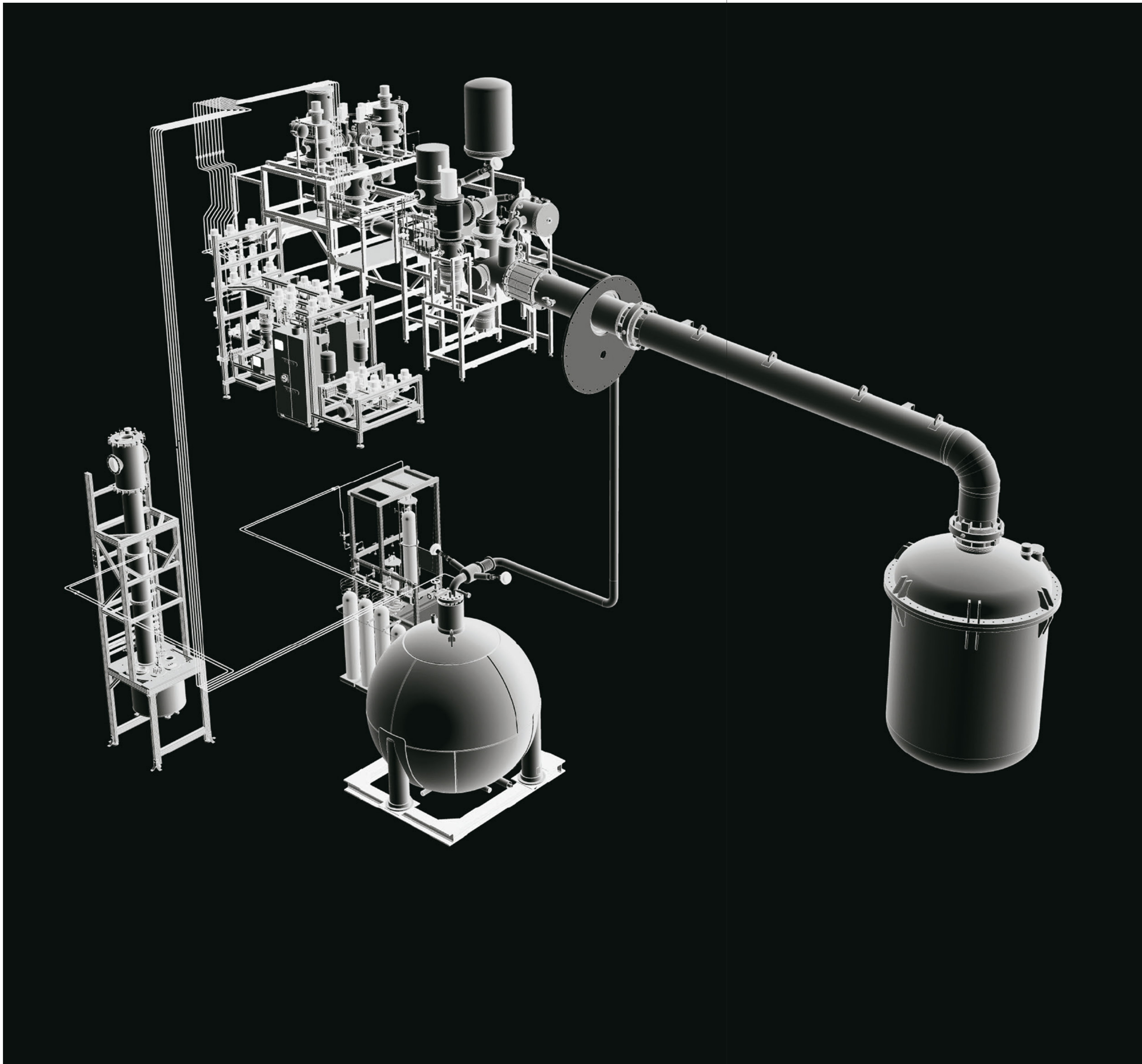
1
Particles



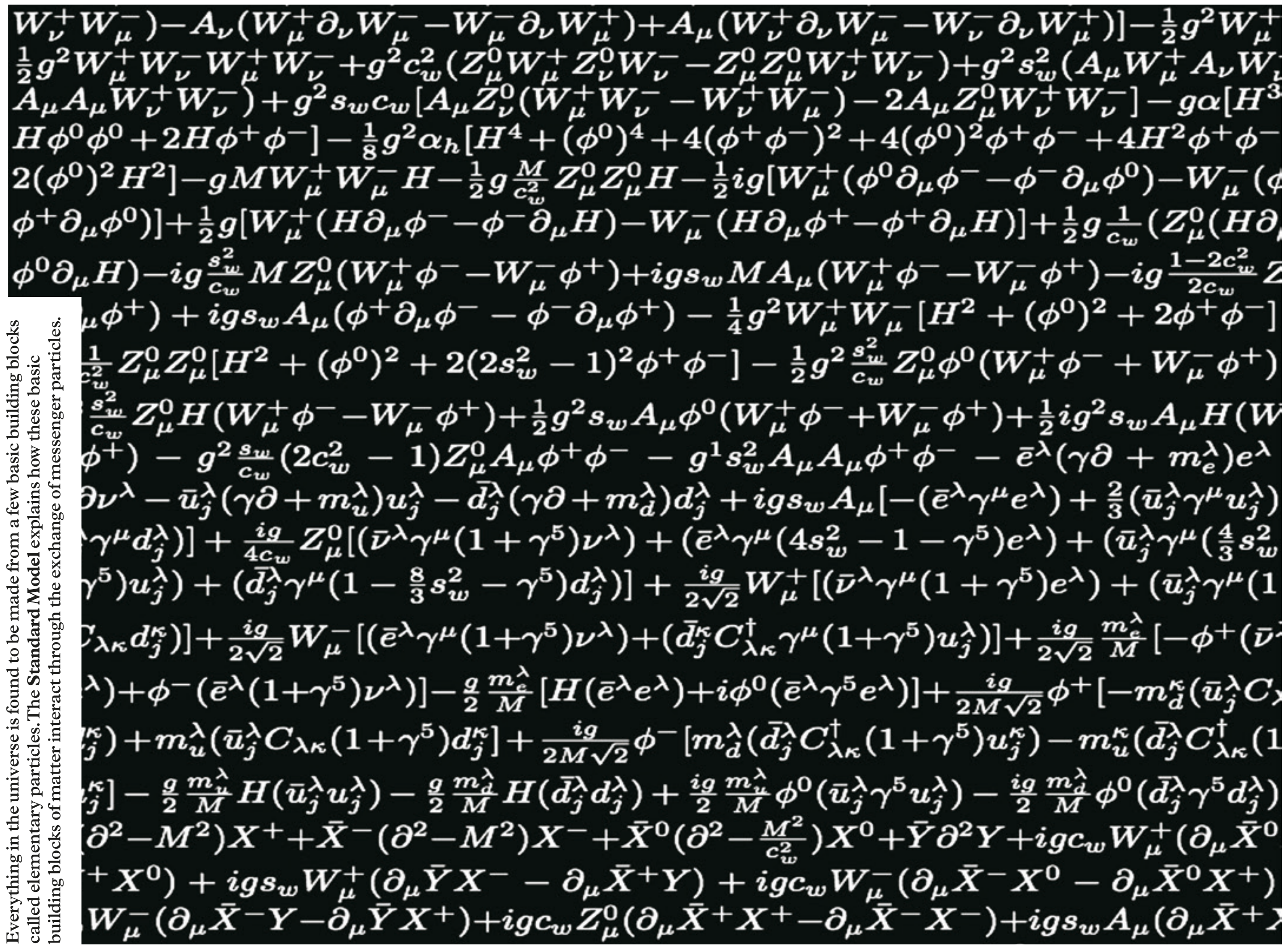
The **Higgs boson** (sometimes also called the 'God particle') is an elementary particle in the Standard Model of particle physics. In the 1960s Peter Higgs was the first person to express the idea of such a particle. The question of its existence became the last unverified part of the Standard Model, and for several decades was considered the central problem in particle physics. Although the 'Higgs field' is believed to permeate the entire universe, proving its existence was far from easy. The Large Hadron Collider at CERN in Switzerland was built to prove or disprove the existence of the Higgs boson. It accelerates two beams of particles, travelling in opposite directions, to almost light speed, before setting them on a path to collide with each other. On 14 March 2012, scientists at CERN confirmed that they had found the particle. The image shows a visualisation of the likelihood function used for measuring properties of the Higgs boson. The likelihood function comprises different components which are all connected in some way. These connections are represented by the lines in the picture. (Nikhef, University of Amsterdam)

Neutrinos are neutral subatomic particles that pass straight through the earth. Scientists attempt to detect neutrinos in order to study their behaviour and the properties of their sources. They do so as part of a collaboration at ANTARES, a neutrino telescope on the bottom of the Mediterranean Sea near France and in a new international project called KM3NeT, short for 'Cubic Kilometre Neutrino Telescope'. KM3NeT consists of hundreds of detection lines of about a kilometre in length. A single line contains 18 Digital Optical Modules (DOMs), the building blocks of the detector. The first lines have been deployed at two sites, at over 2 kilometre depth, near Italy and France. In the next few years hundreds more lines will follow. (Nikhef)





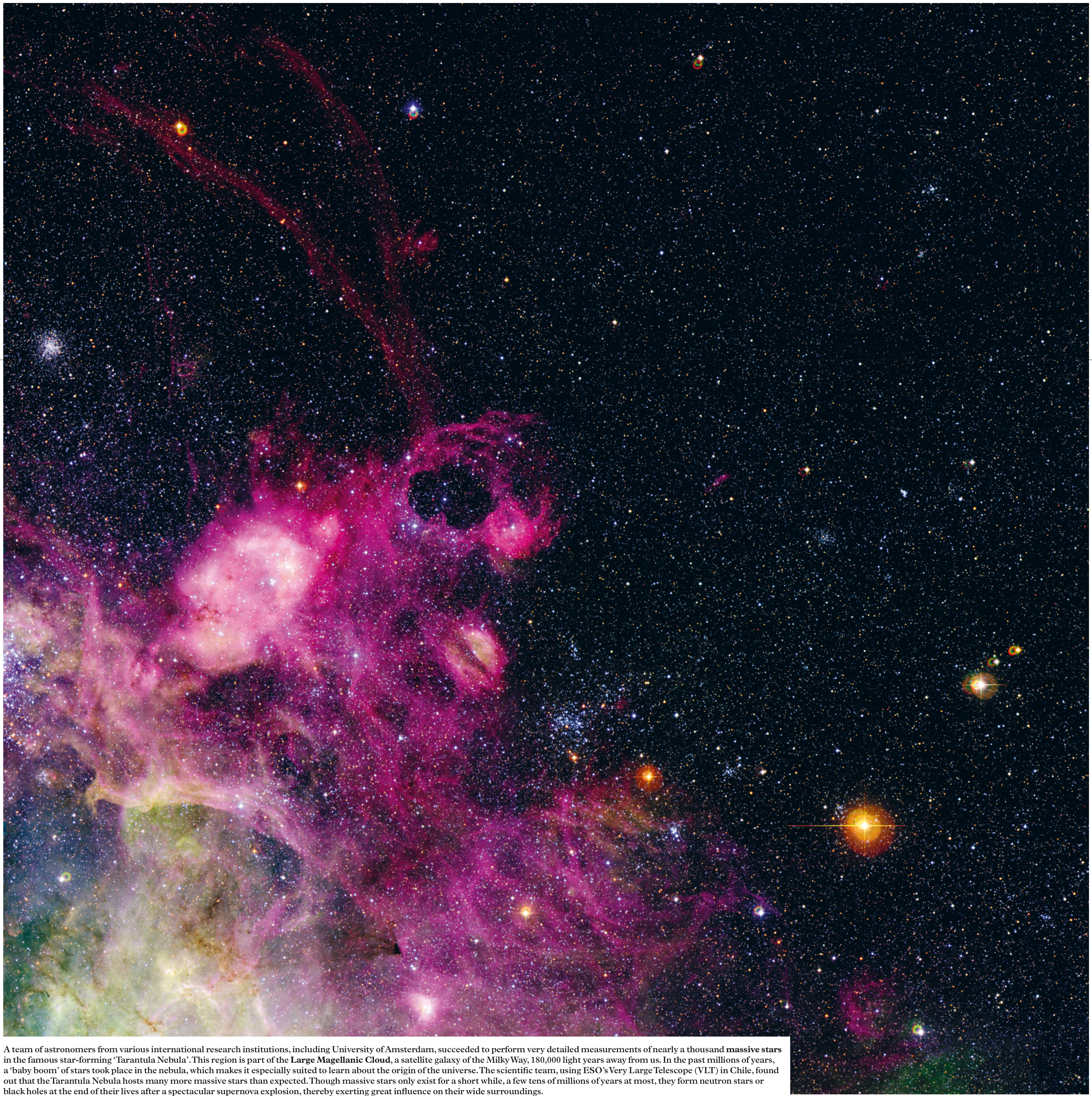
XENON1T, a dark matter detector. The term **dark matter** is used to explain 'missing mass'. It is estimated to make up 85% of the total matter in the universe, while dark energy plus dark matter make up 95%. Scientists believe that dark matter consists of some new kind of yet to be discovered elementary particles. The XENON1T experiment is currently the most sensitive dark matter experiment worldwide. It aims to directly detect dark matter particles. The experiment is hosted deep under the ground, in the INFN Laboratori Nazionali del Gran Sasso in Italy. The XENON Collaboration consists of 150 researchers from the Netherlands (Nikhef and University of Amsterdam), the US, Germany, Italy, Switzerland, Portugal, France, Israel, Sweden and the United Arab Emirates.



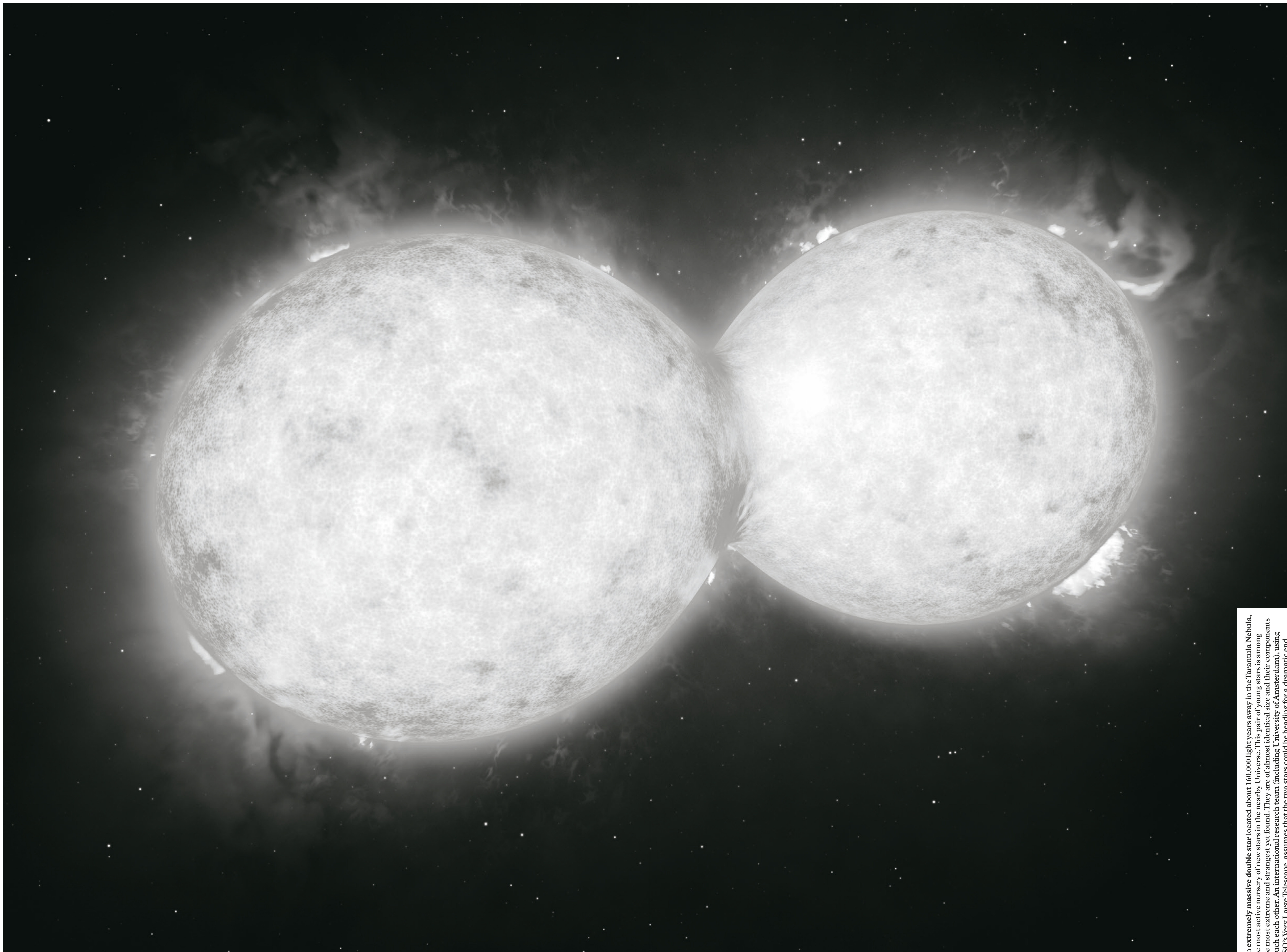
Everything in the universe is found to be made from a few basic building blocks called elementary particles. The **Standard Model** explains how these basic building blocks of matter interact through the exchange of messenger particles.

Theoretical physicists perform theoretical research on a wide range of fundamental topics in high-energy physics, ranging from particle and astroparticle physics to cosmology, gravitational waves and string theory. The advancement of science generally depends on the interplay between experimental studies and theory. (Nikhef)

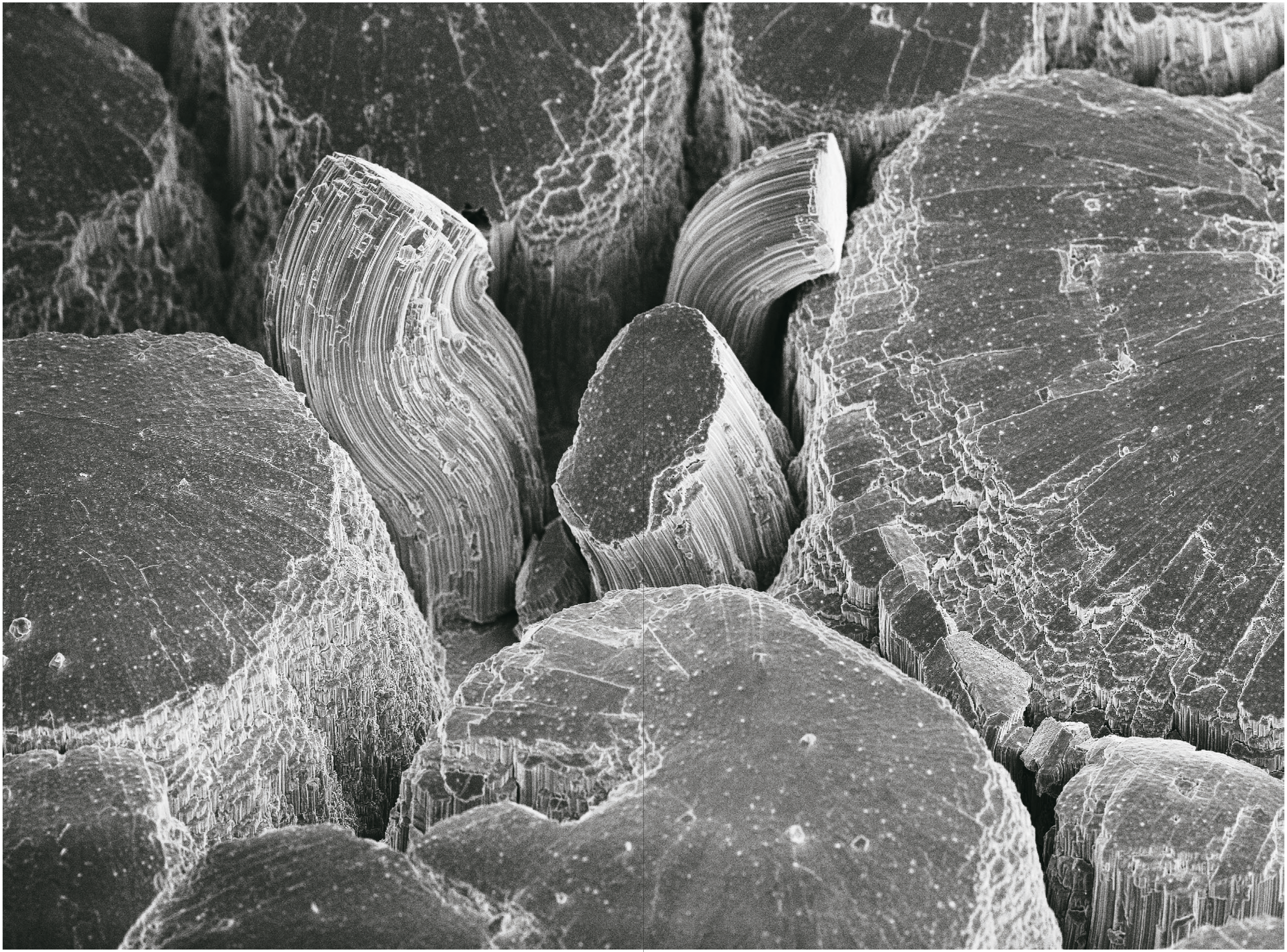
About: Aqueous Systems, Astronomy, Atoms, Black Holes, Companion Stars, Emergent Materials, Galaxies, Large Magellanic Cloud, Light, Massive Stars, Metamaterials, Milky Way, Molecules, Nanophotonics, Nanoscale, Neutron Stars, Origami, Quantum Matter, Soft Robotics, Solar Cells, Spatial Structures, Supernova, Tarantula Nebula, Ultrahigh Vacuum, Universe, Very Large Telescope, Wavelengths

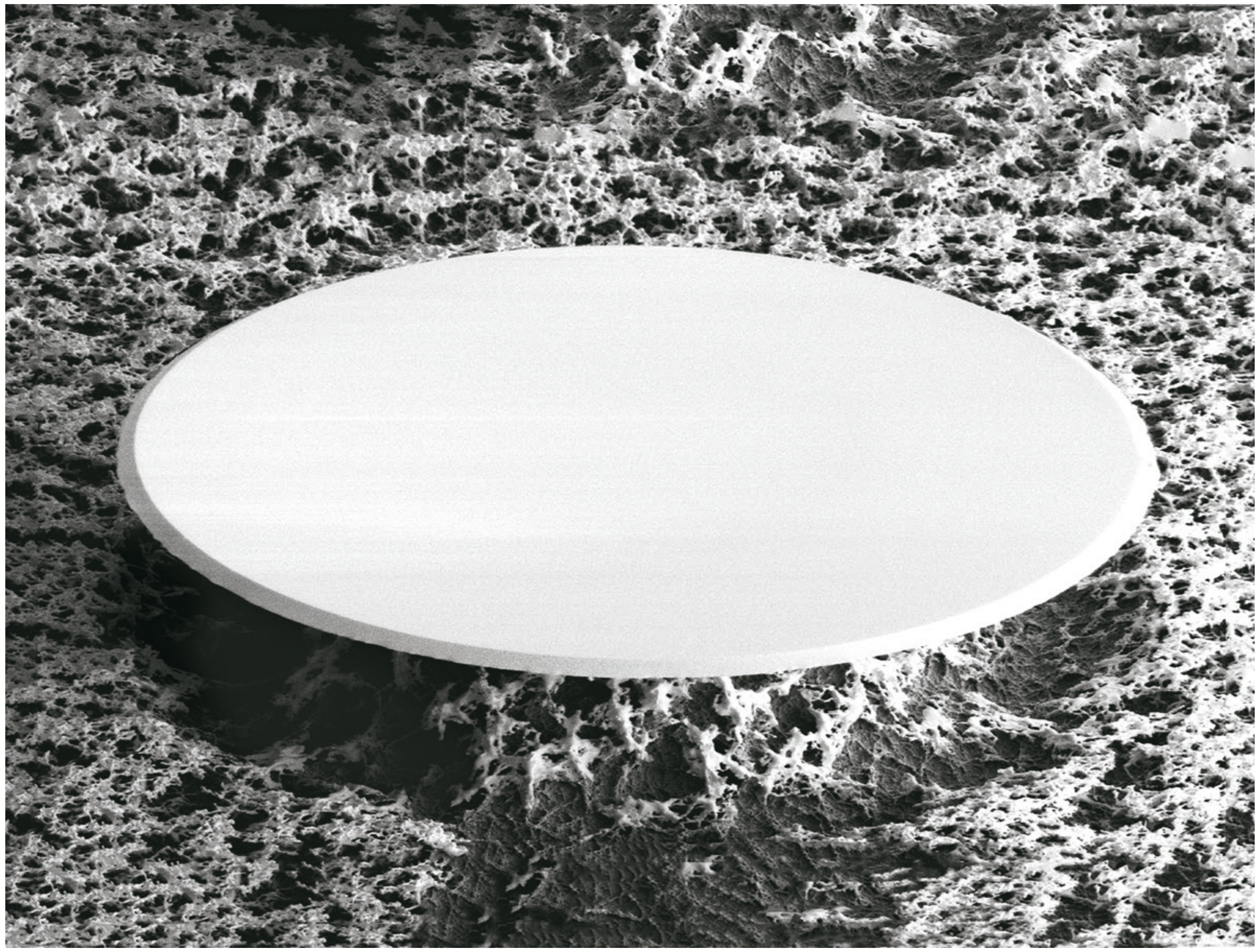


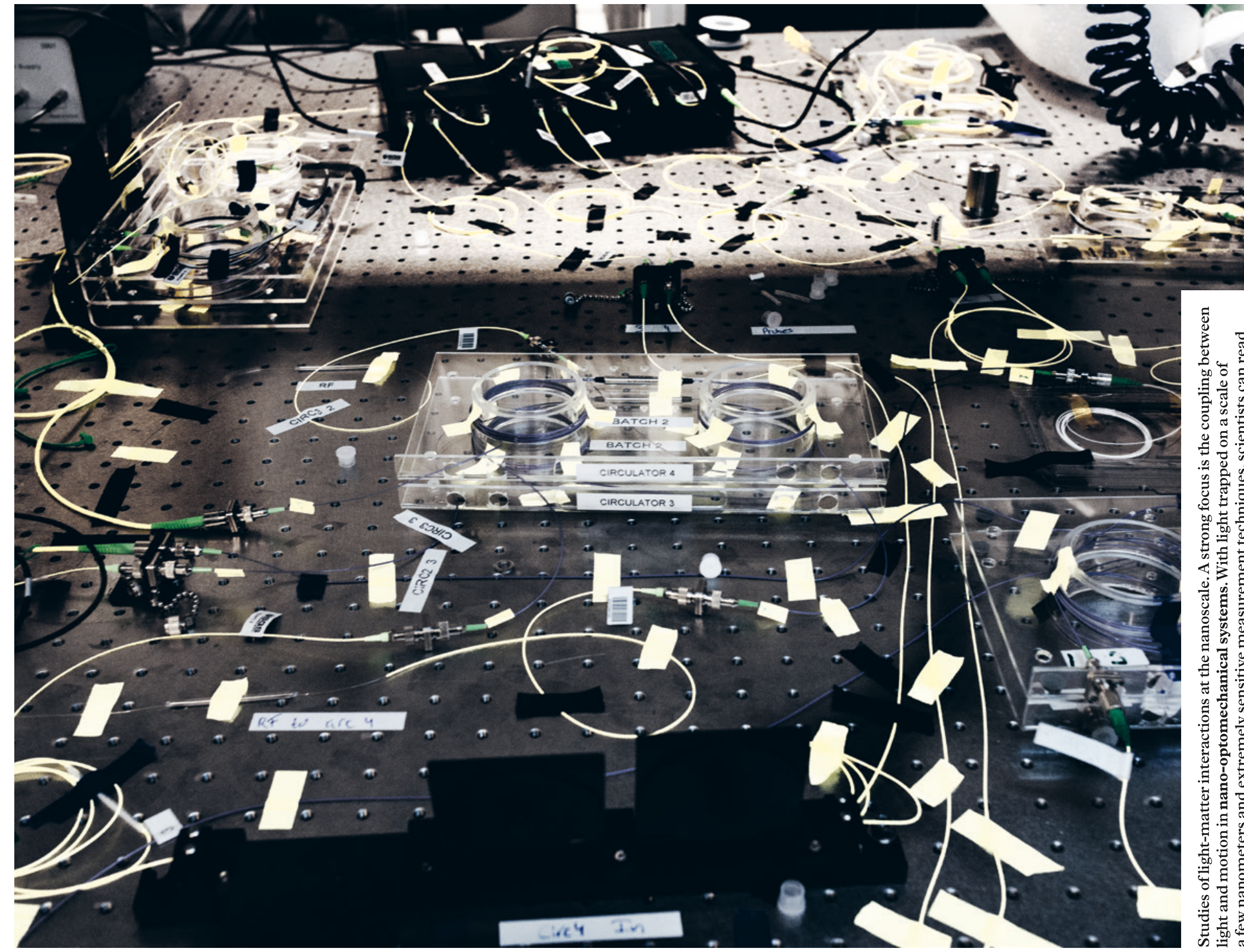
A team of astronomers from various international research institutions, including University of Amsterdam, succeeded to perform very detailed measurements of nearly a thousand **massive stars** in the famous star-forming 'Tarantula Nebula'. This region is part of the **Large Magellanic Cloud**, a satellite galaxy of the Milky Way, 180,000 light years away from us. In the past millions of years, a 'baby boom' of stars took place in the nebula, which makes it especially suited to learn about the origin of the universe. The scientific team, using ESO's Very Large Telescope (VLT) in Chile, found out that the Tarantula Nebula hosts many more massive stars than expected. Though massive stars only exist for a short while, a few tens of millions of years at most, they form neutron stars or black holes at the end of their lives after a spectacular supernova explosion, thereby exerting great influence on their wide surroundings.



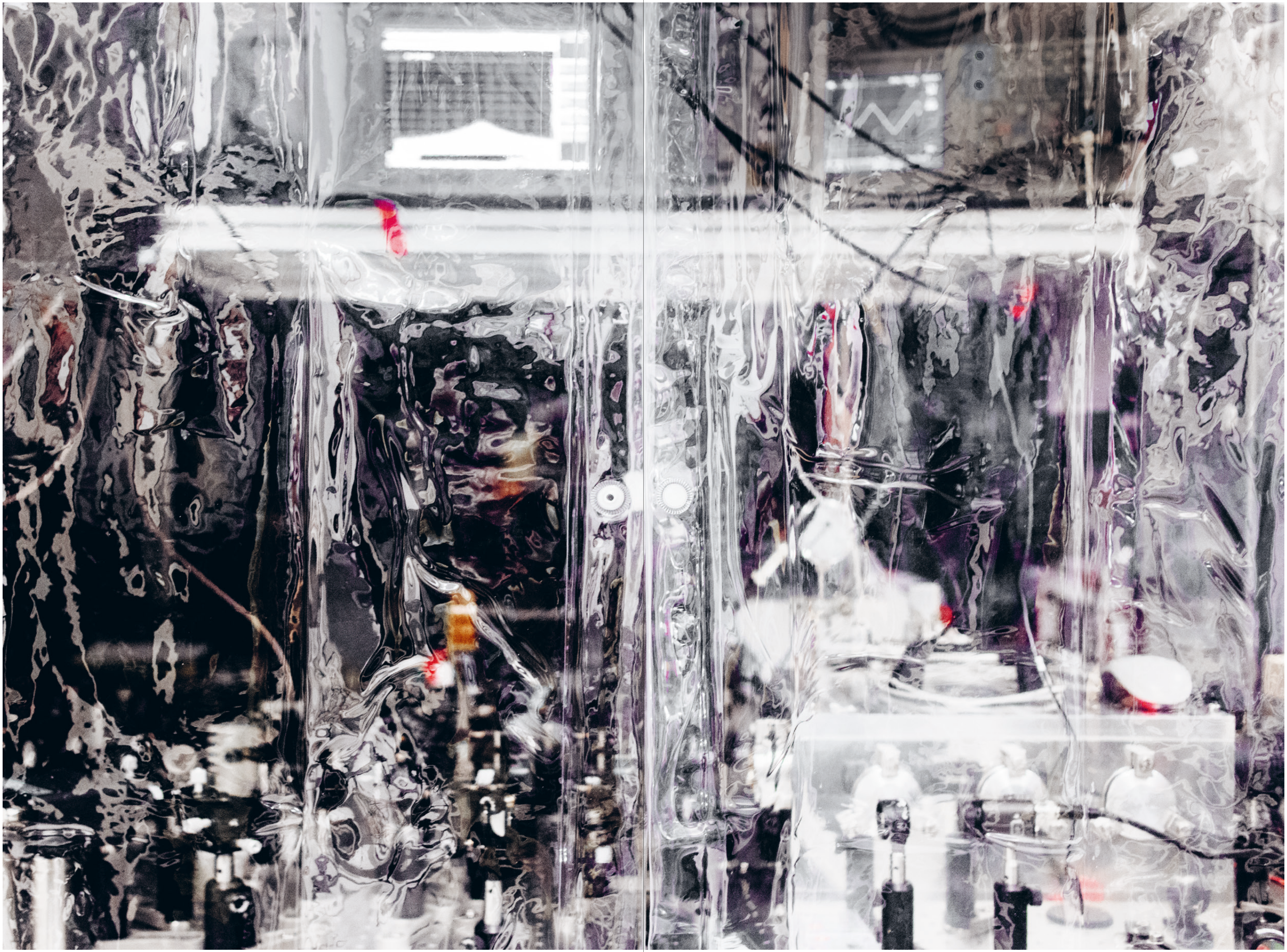
An **extremely massive double star** located about 160,000 light years away in the Tarantula Nebula, the most active nursery of new stars in the nearby Universe. This pair of young stars is among the most extreme and strangest yet found. They are of almost identical size and their components touch each other. An international research team (including University of Amsterdam), using ESO's Very Large Telescope, assumes that the two stars could be heading for a dramatic end, during which they either coalesce to create a single giant star, or form a binary black hole.





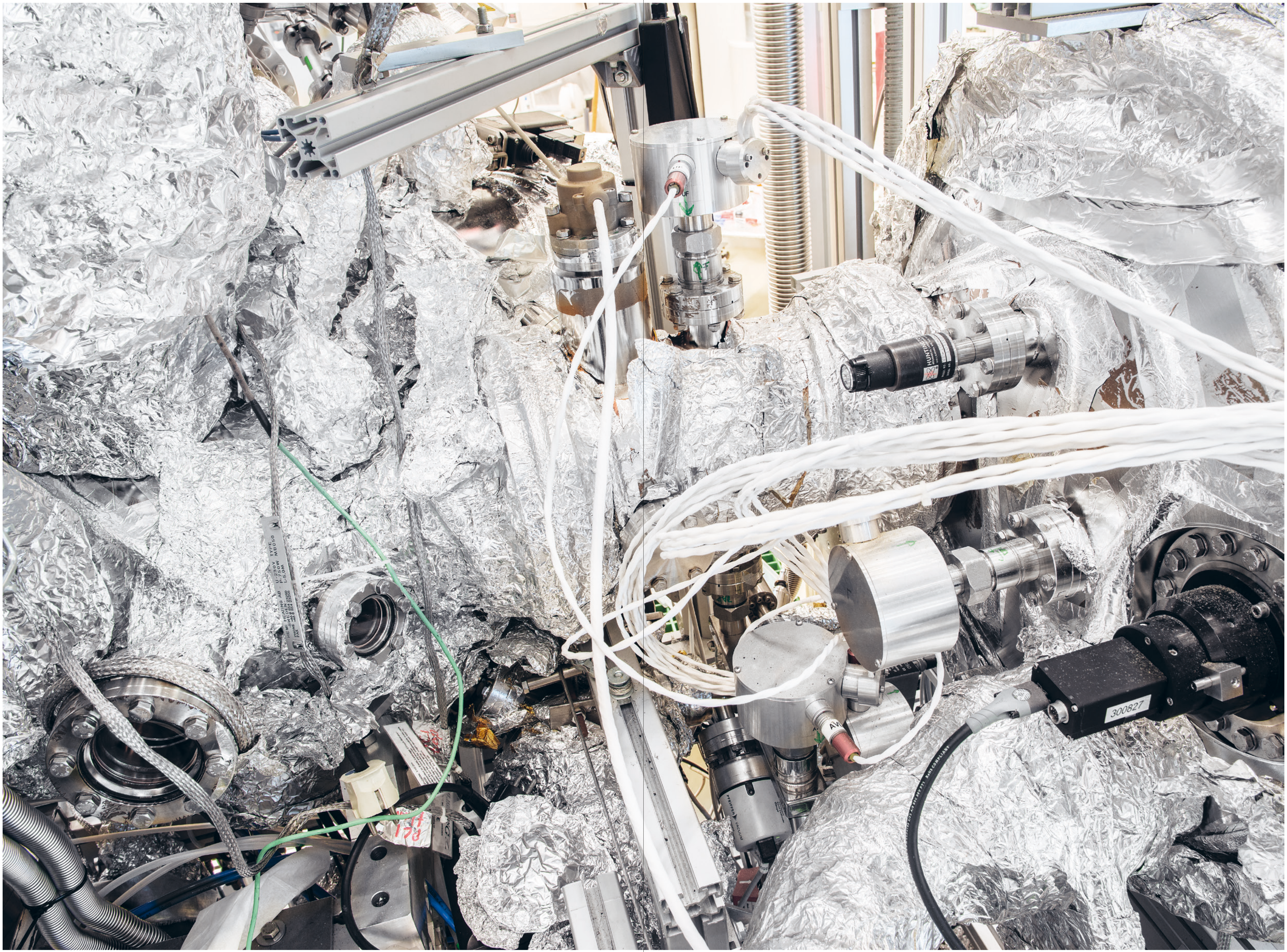


Studies of light-matter interactions at the nanoscale. A strong focus is the coupling between light and motion in **nano-optomechanical systems**. With light trapped on a scale of a few nanometers and extremely sensitive measurement techniques, scientists can read vibrations with a precision smaller than the diameter of the core of an atom. (AMOLF)



Scientific study of the **molecular-scale properties of water**, ice and aqueous systems like hydrated ions, membranes and proteins. The research is carried out using various spectroscopic techniques. (AMOLF)


INSTRON
LOAD CELL
STATIC RATING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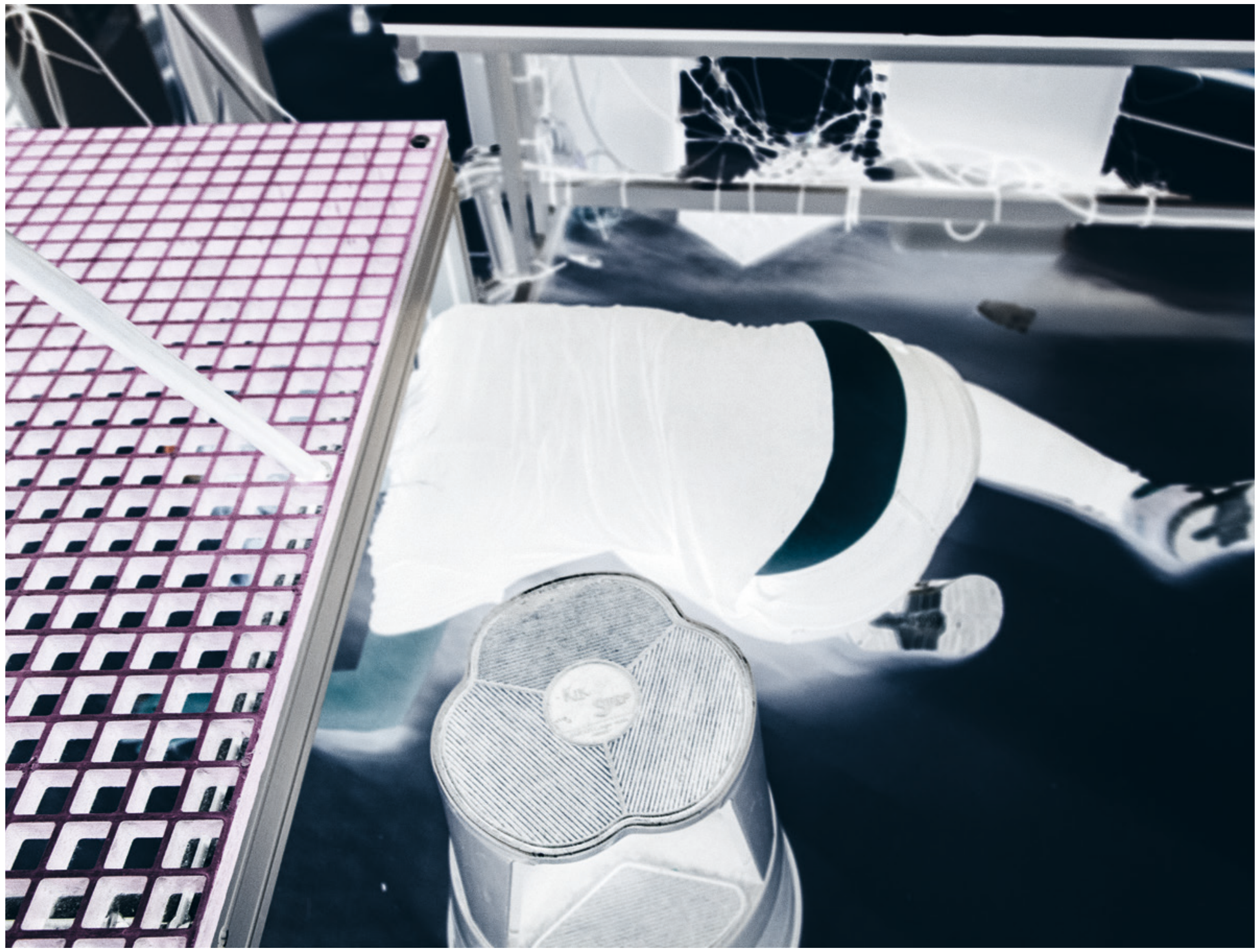
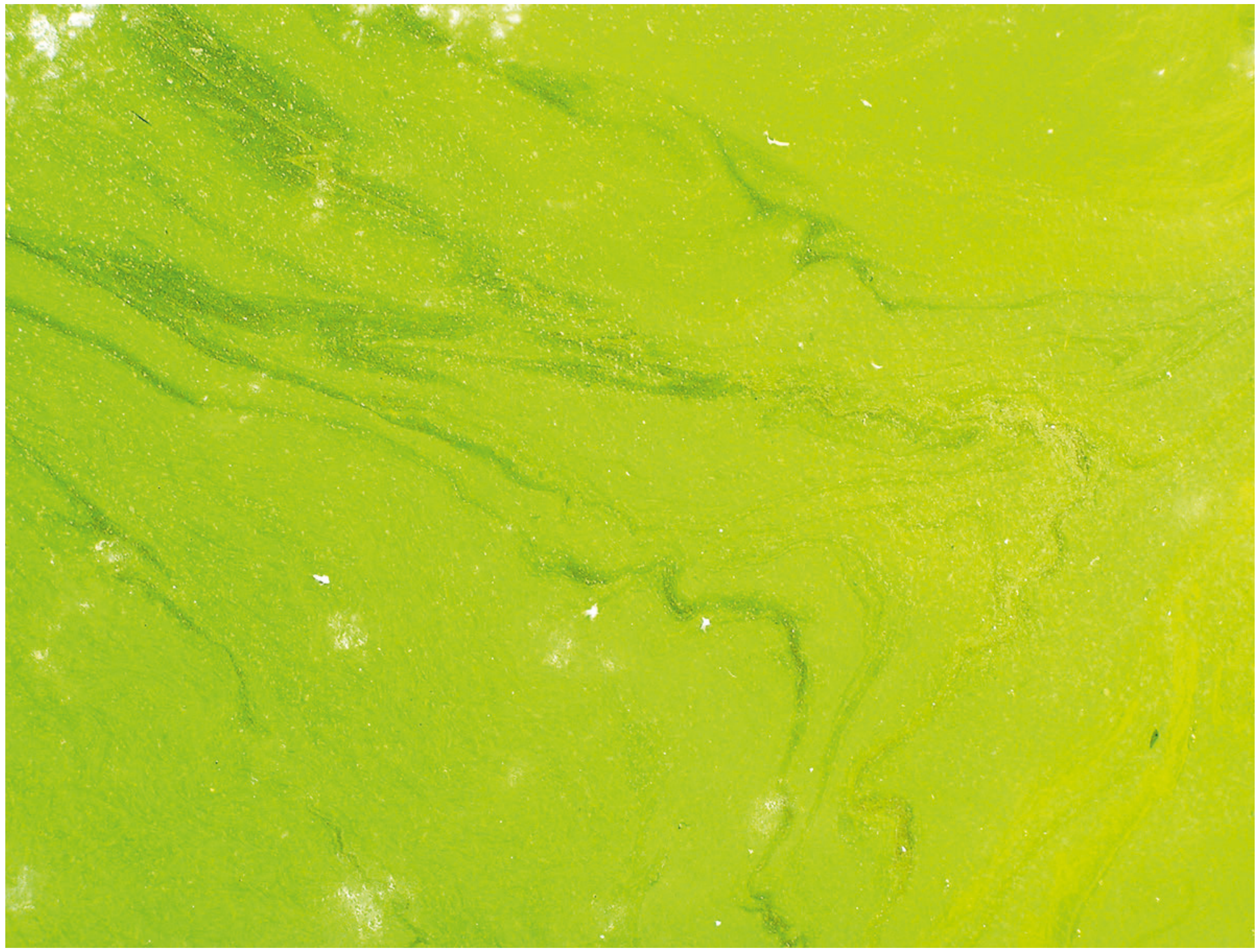
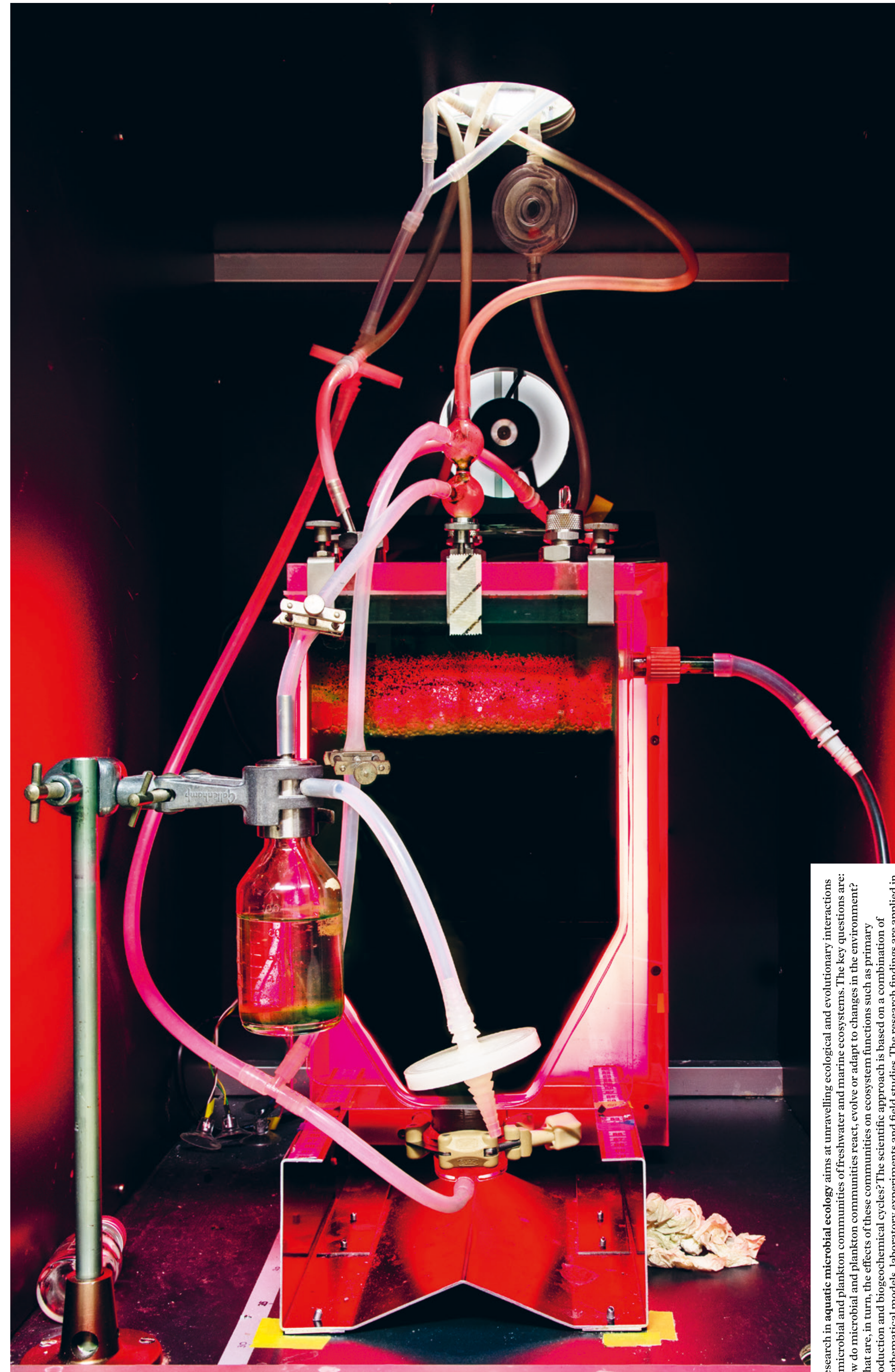


3 Organisms

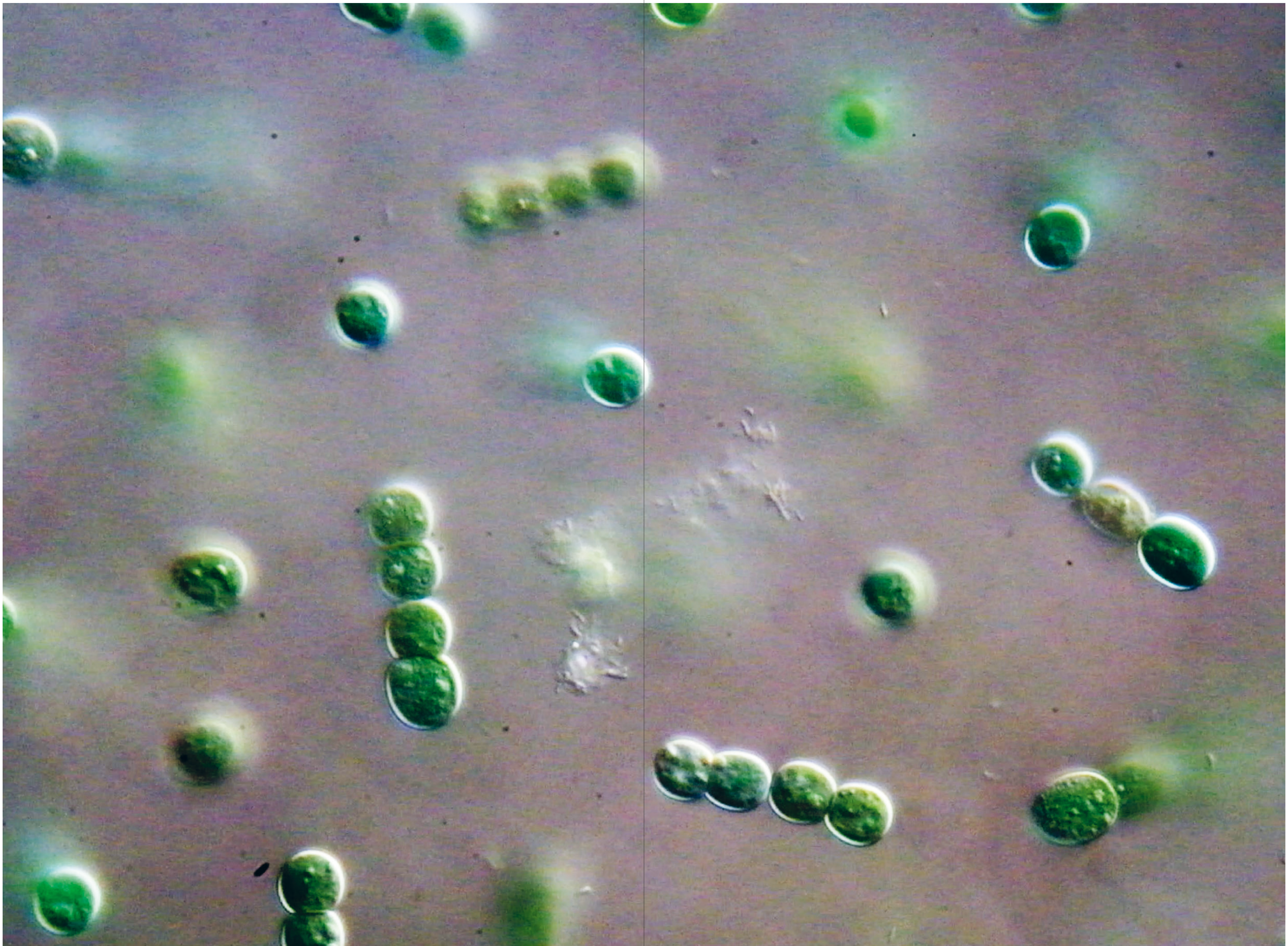
Research focused on understanding **tumour initiation and progression.** The test tube contains a mouse mammary gland sample. (University of Amsterdam)

Normally, tight control of cell proliferation and differentiation ensures the correct assembly of cells into complex tissues. When this biological process is disrupted, it can be the underlying cause of diseases, such as **cancer**. Using a combination of in vitro and in vivo approaches, the research is particularly directed at the behaviour and control of intercellular signals. CRISPR/CAS9 technology is used to modify genes involved in intercellular signalling, in order to visualise this process at the molecular level in real time on the basis of advanced microscopy. (University of Amsterdam)

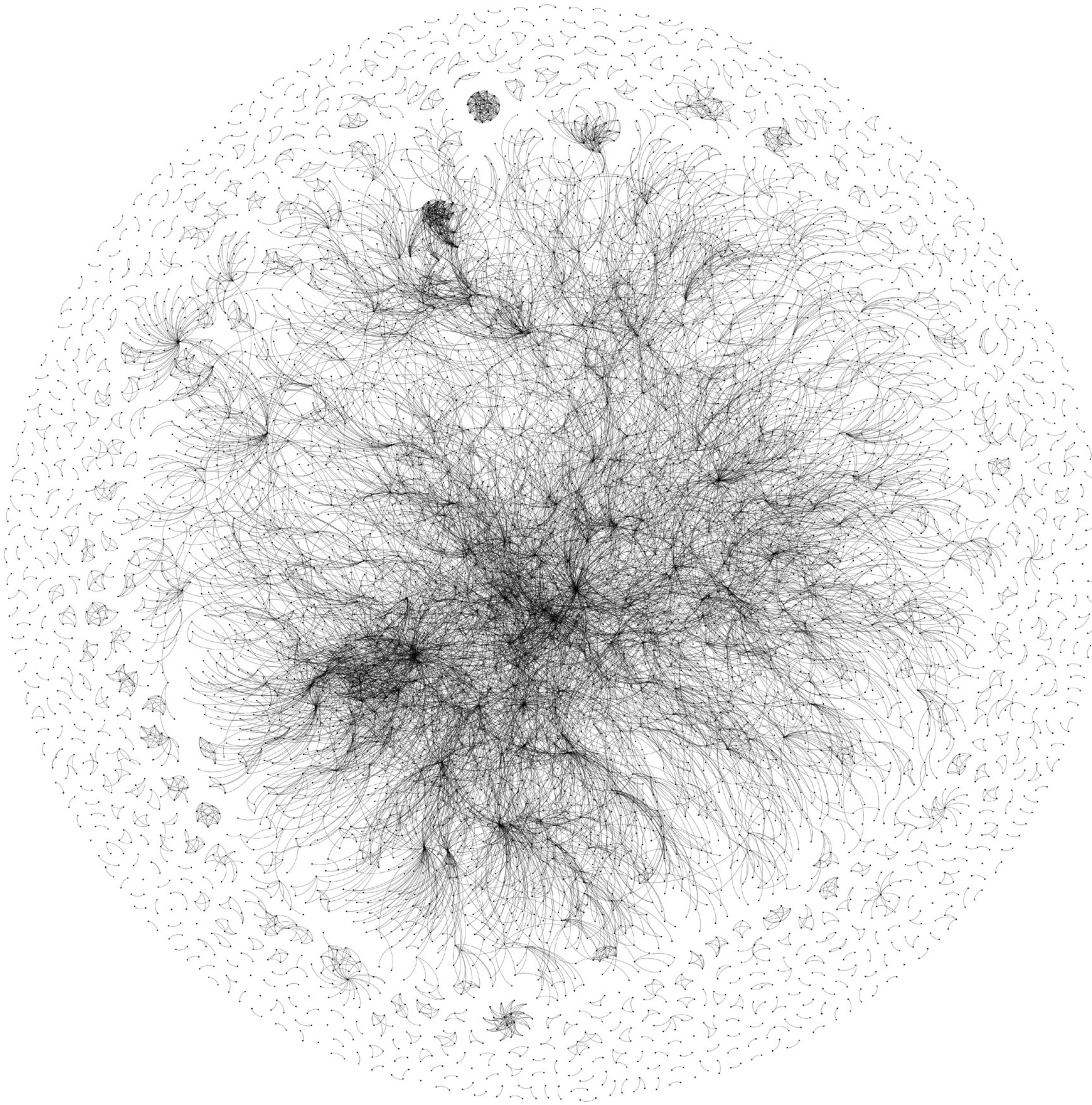




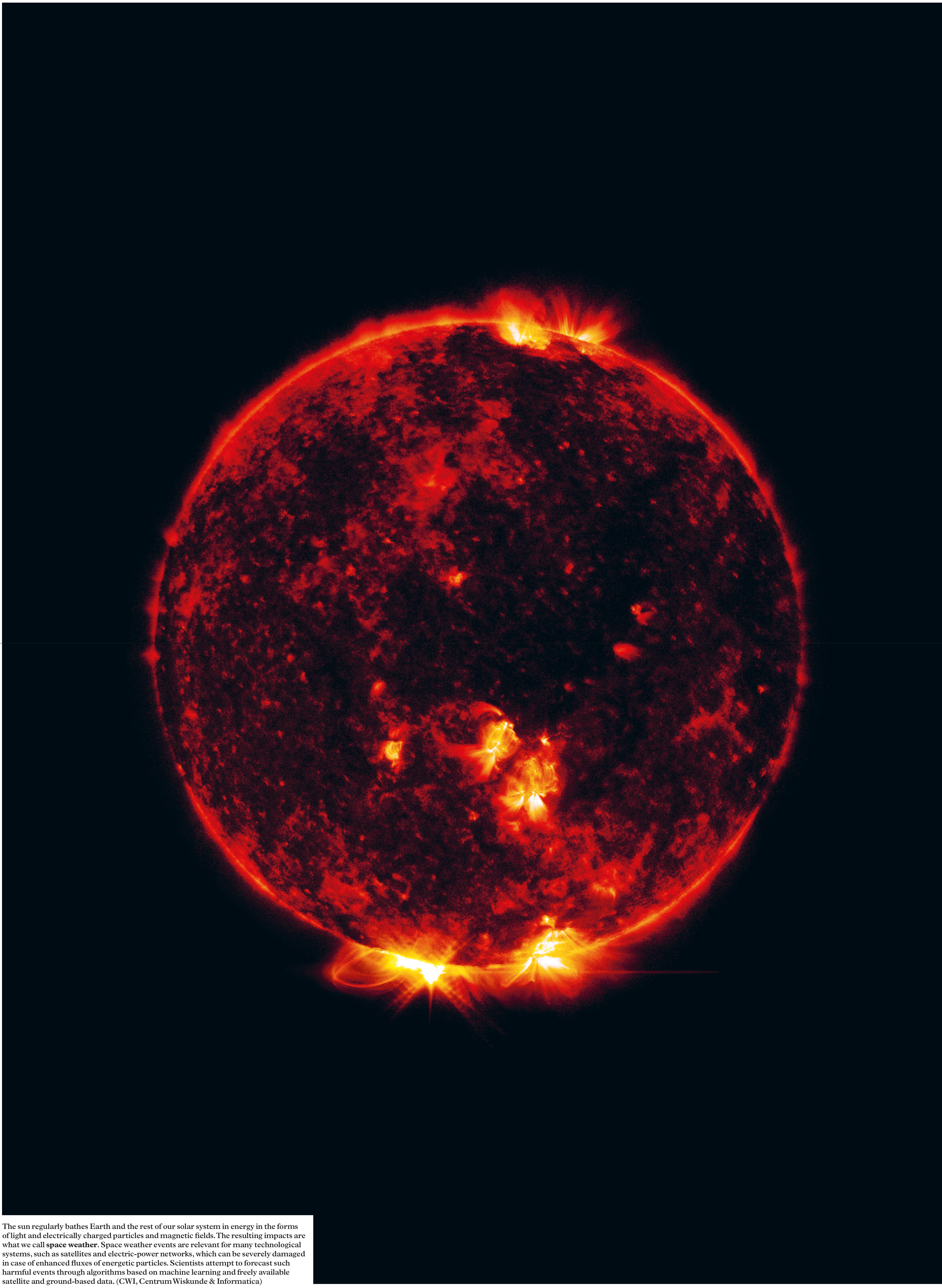
Research in **aquatic microbial ecology** aims at unravelling ecological and evolutionary interactions in microbial and plankton communities of freshwater and marine ecosystems. The key questions are: how do microbial and plankton communities react, evolve or adapt to changes in the environment? What are, in turn, the effects of these communities on ecosystem functions such as primary production and biogeochemical cycles? The scientific approach is based on a combination of mathematical models, laboratory experiments and field studies. The research findings are applied in algal biotechnology, water management and climate change research. (University of Amsterdam)



Contemporary scientific research is facilitated by **high performance computing** and data infrastructure. These activities take place in data centres. An example is Amsterdam Data Tower, completed in 2016 and hosting a number of research institutes as well as commercial organisations. It is located at Amsterdam Science Park which is home to more than 150 network hubs including AMS-IX (the largest data transport hub in the world). Fifteen sub-sea cables connect the Americas to the Netherlands. The 72m-tall data tower has 5,000 m^2 of data space on 13 floors, and 9MW of power. The building uses outside air and groundwater for cooling, and also stores warm water underground. The image shows 'Cartesius', the Dutch national super-computer, a general-purpose capability system containing a combination of fast processors and internal network, large storage capacity and the ability to process large datasets. (SURFsara)



We live in a highly connected world and are surrounded by a large diversity of **complex systems.** All these systems have one thing in common – they process information. Scientists aim to detect and describe the computational structure in these dynamic processes and attempt to provide a quantitative characterisation of the essential aspects of their structure. The scientific challenges include data-driven modelling of multi-level systems and their dynamics as well as conceptual, theoretical and methodological foundations that are necessary to understand these processes and the associated predictability limits of such large-scale computer simulations. The image shows the **sociograph of a criminal network** under study. (University of Amsterdam)



The sun regularly bathes Earth and the rest of our solar system in energy in the forms of light and electrically charged particles and magnetic fields. The resulting impacts are what we call **space weather**. Space weather events are relevant for many technological systems, such as satellites and electric-power networks, which can be severely damaged in case of enhanced fluxes of energetic particles. Scientists attempt to forecast such harmful events through algorithms based on machine learning and freely available satellite and ground-based data. (CWI, Centrum Wiskunde & Informatica)

Eyelashes and Black Holes

Jos Jansen

Facts in the post-truth era

The relationship between people, nature, technology and science has fascinated me since early childhood. In particular, the concept of man constantly working to expand his boundaries has always intrigued me. Later, I grew interested in all the purely fundamental scientific research it takes to achieve that. Such research generally seems to yield decades of nothing more than 'useless' knowledge, but at some point suddenly helps to generate a breakthrough that transforms the world, causing people's lives to change beyond recognition. But what is fundamental research in essence? Where does it take place and what does it look like? What are the great mysteries that scientists currently struggle to comprehend? And what do scientific facts mean in a world of alternative facts?

Anthropological

For 18 months, from autumn 2016 to spring 2018, I had the opportunity to research exactly what fundamental science truly entails. In this period, I was able to explore freely in the universe of one of the biggest concentrations of exact science in Europe: Amsterdam Science Park. This scientific cluster in the northeast of the city is situated in a fringe location that many Amsterdam locals find a bit too windy for their taste. Amsterdam Science Park marks the intersection of renowned institutes of higher education, high-quality research institutes, and knowledge-intensive businesses. While I was working on this documentary project, I frequently had to think of Bruno Latour. This French philosopher and anthropologist of science spent over two years in the 1980s in a microbiology

about the artist

Jos Jansen studied psychology as well as documentary photography and film. Although he always uses reality as his point of departure, his work is personal and subjective. Bridges the gap between reality and fiction, documentary reporting and the visual arts. Over the past six years, Jansen has published five photo books, four of which with The Eriskay Connection: *Entering the Black Box* (2012), *Seeds* (2014), *Battlefields* (2015) and *Universe* (2018). *Seeds* was acclaimed in the Netherlands as one of the best photo books of 2014. *Battlefields* was acquired by the Metropolitan Museum of Modern Art in New York and nominated for the Prix du Livre 2016 at the Rencontres d'Arles photography Festival in France.

colophon

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Prof. Robbert Dijkgraaf

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Jos Jansen & Rob van Hoesel

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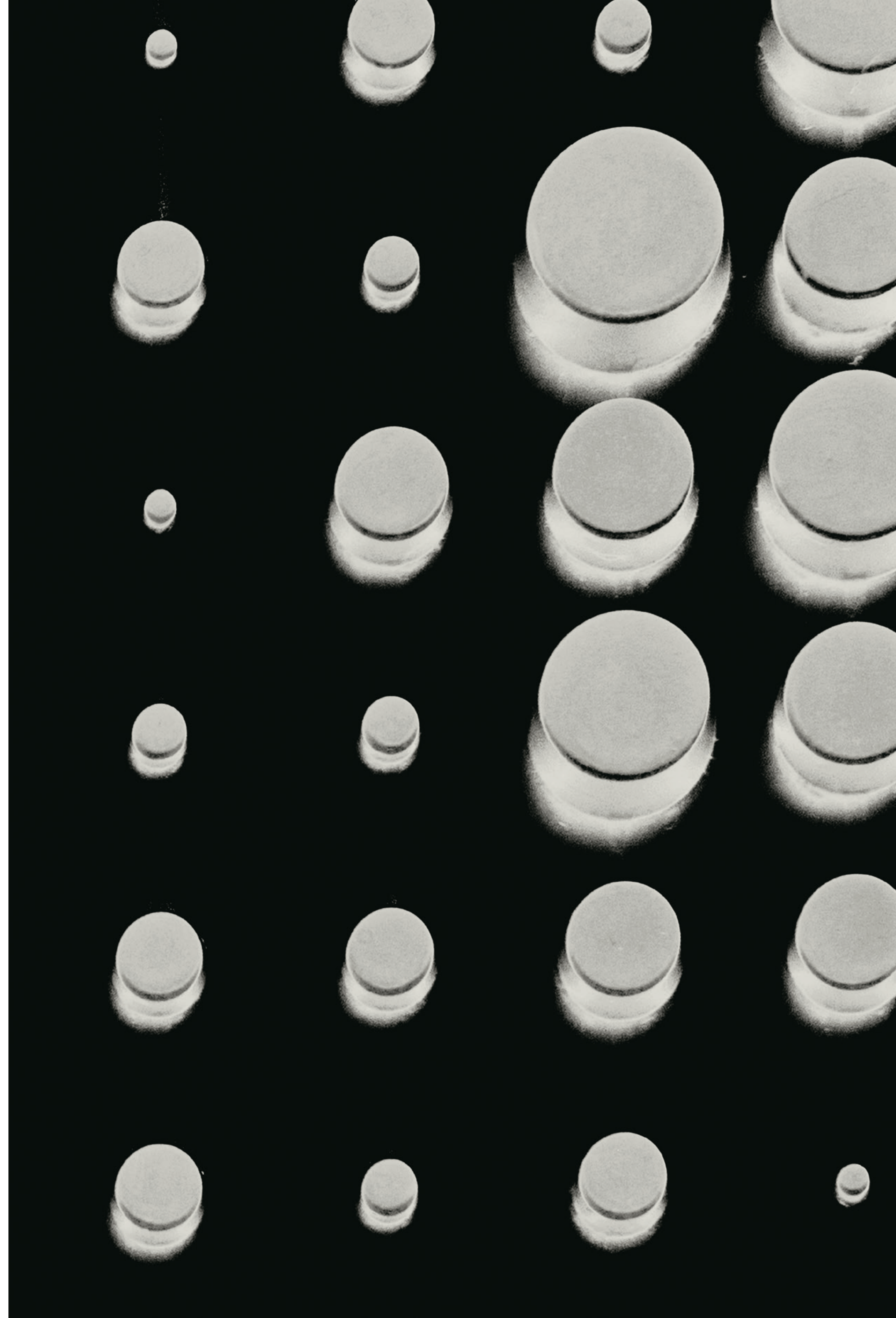
note

Both the outside walls and the walls of the indoor courtyards at Amsterdam University are covered with dot patterns. These patterns symbolically represent living cells, as can be observed under a microscope.



Universe is about curiosity, comprehending, and knowing. Knowledge for the sake of knowledge. Comprehending for the sake of comprehending. Fundamental scientists as modern explorers. Pioneers who are trying to understand the world and waging a war on mortality. But what are the major mysteries that they grapple with now? And what do scientific facts mean in a world of fake news and alternative facts?

In *Universe*, Jos Jansen explores research topics in the domain of hard science, like dark matter and new galaxies. His explorations also extend to genetic research, soft robotics, and artificial intelligence. Jansen observes and documents the passionate quest for seemingly useless knowledge – the type of knowledge that often takes many years to result in a crucial breakthrough that changes the world and helps people lead completely different lives. In this nearly incomprehensible world, he builds a parallel, artistic universe using his own images, found footage, and data visualisations.

Introduction by Professor Robbert Dijkgraaf, director of the Institute for Advanced Study and Leon Levy Professor, Princeton, US.

The Eriskay Connection
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