EXPERIMENTNL

SCIENCE IN THE NETHERLANDS

LIGHTNING GENERATES ANTIMATTER NINE SCIENCE LESSONS TO IMPROVE LEARNING **NO QUANTUM COMPUTER WITHOUT SPECIAL SOFTWARE** SCIENTIFIC NEIGHBOURLY HELP AT THE AMSTERDAM SCIENCE PARK **VINCENT VAN GOGH'S WORK IS FADING: CAN THE TIDE BE TURNED?** WHY WOMEN'S FOOTBALL IS LAGGING BEHIND MEN'S FOOTBALL

NWO
Netherlands Organisation for Scientific Research

One big experiment

t's usually only evident how important a year has been for science after it has passed. But already 2015 seems to have been especially important. After two years of maintenance and fine tuning, CERN's particle accelerator, the Large Hadron Collider, began operations again. The particles are now flying around with twice as much energy as before. By letting the particles collide, the physicists at CERN hope to discover new phenomena as exciting as the confirmation of the Higgs boson in 2012.

Perhaps dark matter is next in line. Are we on the threshold of a revolution in physics? Only the experiments will be able to answer that question.

And that goes for all scientific subjects, not just particle physics. Sometimes we find answers that allow us to take a step forward. But these answers inevitably raise new questions. In fact, we're never done learning.

The Netherlands is the forefront of science, and our researchers are doing great work. This magazine provides many excellent examples of that.

Microscopic analysis of a Van Gogh painting has shown how the work's irises have discoloured and what we can do to restore the colour (see page 38). Materials are being manipulated at a nano-level in experiments. Yet other experiments are pushing the boundaries of our knowledge of the cosmos by detecting neutrinos, messengers from the depths of the universe (see page 52).

The Netherlands Organisation for Scientific Research (NWO) makes funds available for researchers whose work takes small but sometimes major steps forward for us. It's fascinating to pause and reflect on the progress that they're making. NWO also encourages scientists to work together. With each other, but also with businesses. Indeed, because science is continuously raising new questions, we'll only make significant advances if scientists share their knowledge.

As chair of NWO, I am privy to developments in this exciting world every day. I would like to share them with you. That's why I feel privileged to offer you Experiment NL again this year, produced in collaboration with Quest. This magazine demonstrates what science means in the Netherlands. I can't tell you where it will all end, because science is one big experiment.

Jos Engelen
Chair NWO

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ALSO IN *EXPERIMENT NL*

Strengthening ties

About NWO

The Netherlands Organisation for Scientific Research (NWO) funds the work of some 7,000 researchers, which makes it one of the most important science funding bodies in the Netherlands. NWO also runs eight research institutes, all of which are centres of expertise in specific scientific fields. The NWO divisions jointly promote strong ties between those working in the world of science and between science, society and industry.

NIOZ
NIOZ Royal Netherlands Institute for Sea Research

ASTRON
ASTRON Netherlands Institute for Radio Astronomy

SRON
SRON Netherlands Institute for Space Research

AMOLF
FOM institute AMOLF

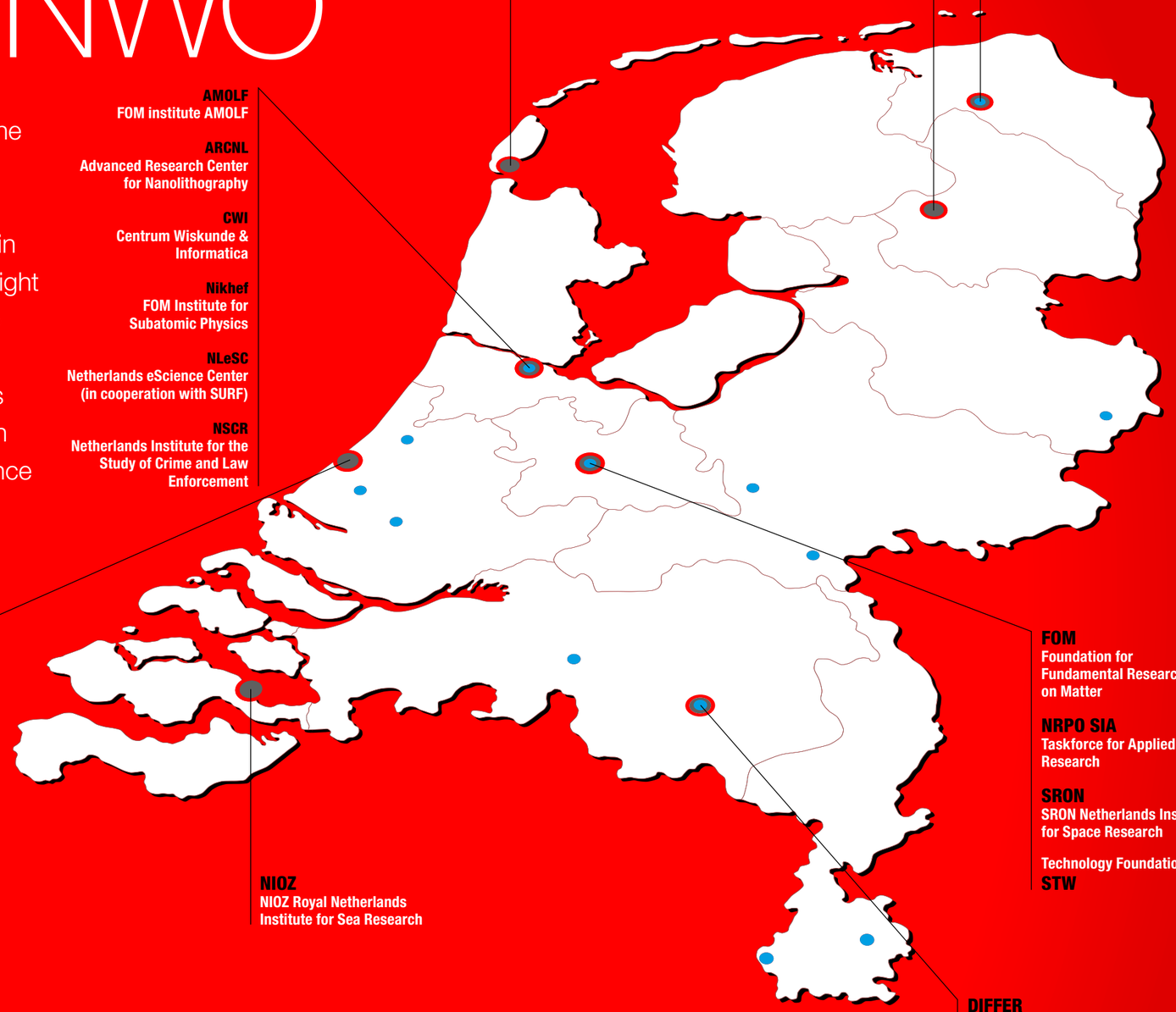
ARCNL
Advanced Research Center for Nanolithography

CWI
Centrum Wiskunde & Informatica

Nikhef
FOM Institute for Subatomic Physics

NLeSC
Netherlands eScience Center (in cooperation with SURF)

NSCR
Netherlands Institute for the Study of Crime and Law Enforcement



NWO THE HAGUE
Earth and Life Sciences (ALW)
Chemical Sciences (CW)
Physical Sciences (EW)
Humanities (GW)
Social Sciences (MaGW)
Medical Sciences (accommodated at ZonMw Netherlands Organisation for Health Research and Development)
Physics (N – largely though the FOM Foundation)
Technical Sciences (accommodated at Technology Foundation STW)

WOTRO Science for Global Development

DANS
Data Archiving and Networked Services (in cooperation with KNAW, the Royal Netherlands Academy of Arts and Sciences)

NIHC
National Initiative Brain & Cognition

NRO
Netherlands Initiative for Education Research

NIOZ
NIOZ Royal Netherlands Institute for Sea Research

FOM
Foundation for Fundamental Research on Matter

NRPO SIA
Taskforce for Applied Research

SRON
SRON Netherlands Institute for Space Research

Technology Foundation **STW**

DIFFER
Dutch Institute for Fundamental Energy Research

Universities
NWO divisions

2014 NWO BUDGET: €820 MILLION
Where do the funds come from?

NWO RESEARCH IN 2014:

5,762 research projects ongoing or completed

16,131 publications

Research proposals given funding in 2014:

1,209 (out of 4,989 submitted requests)

Curiosity-driven research and talent programmes (e.g. Veni, Vidi and Vici): **597x**

Research on specific themes, such as cybersecurity or the climate, and research on the use of research results outside science: **465x**

Research infrastructure, such as databases and telescopes: **147x**

Dutch research contributes to development of cystic fibrosis medicine

Putting an end to **mucus**

An incorrectly folded protein in the cell and a cleaning mechanism that wants to get rid of it as quickly as possible: the result is a build-up of mucus in the lungs of cystic fibrosis patients. For the first time in centuries a cure for this disorder is on the horizon.

TEXT: HIDDE BOERSMA

People with cystic fibrosis need a special apparatus to take their daily medicine.

The heel-prick test screens babies for cystic fibrosis, among other things.

‘Woe to the child who tastes salty from a kiss on the brow, for he is cursed and soon must die.’ German and Swiss doctors described the symptoms of a disease, which would later be named cystic fibrosis, for the first time in the eighteenth century. Babies who suffer from the disorder have extremely salty sweat because their water and salt levels aren’t regulated properly. The result is a build-up of mucus, especially in the lungs and pancreas. That causes blockages in the organs and makes them extremely sensitive to infection. In the eighteenth century babies with cystic fibrosis frequently died soon after birth. Indeed, it was a miracle for a child to reach the end of puberty. There is still no cure for the disorder, but nowadays many patients reach the age of forty by having the symptoms treated. At that point, a lung transplant is frequently the only way to prolong life.

At the time, German and Swiss doctors still had no idea what caused the disorder. It took approximately 200 years before scientists got a glimpse of the first piece of the puzzle. ‘Cystic fibrosis turns out to be a protein-folding disease,’ says Ineke Braakman, professor of cellular protein chemistry at Utrecht University. Proteins are the workhorses of our cells: they perform most of the tasks that allow cells to function and allow our organs and body to work the way they work. Proteins are produced in the cell as a chain of beads of amino acids, but they only start to work once the chain has been folded in a certain way. And that’s where things go wrong when someone has cystic fibrosis.

Too rigorous a screening

American scientists first discovered the mutated gene that causes cystic fibrosis in the late 1980s. That genetic fault was traced to a gene called CFTR. This gene contains the code for a protein that nestles itself in the membrane of a cell to create a small hole there. This pore is responsible for allowing mainly chloride ions to flow out of the cell. If the pore is absent or malfunctions, then that will disrupt the cell’s fluid and salt levels. And that’s what ultimately causes the thick mucus that characterises cystic fibrosis to develop in the organs. The gene mutation actually only causes one of the 1,480 beads in the amino acid chain to be absent, but the consequences are far-reaching. The entire folding process of the protein becomes badly unstuck, and as a result can no longer do its job. Other mutations of the CFTR gene that were discovered later cause similar minor changes to the chain of beads. They all cause an imbalance in salt levels. ‘It’s striking that in the lab the membranes of these faulty proteins still seem to be working quite well,’ says Braakman. ‘It’s not only the proteins that cause this disorder but also the cell’s cleaning mechanism.’

This is how it works: when proteins are created, which happens throughout the day, they first face a rigorous assessment committee that checks whether they make the grade before they can be used. This check is there for a reason: if too many bad proteins accumulate in a cell, then that cell will die. ‘But in this case the cleaning mechanism tries just a little bit too hard. Sure, there’s something wrong with the proteins, but it would have been better if the assessment committee had let them through after all, because partial functioning is still better than nothing,’ Braakman says. That’s why all the cells in people with cystic fibrosis lack the function of a key protein. In this case the cure is worse than the ailment. Braakman adds that in some rarer forms of cystic fibrosis the mutated protein is allowed to pass but then doesn’t do its job well.

‘Parents don’t have to spend hours a day any more taking care of their sick child’

Protein that flaps around

Braakman has been studying the folding process of proteins for decades. The CFTR protein caught her attention about ten years ago. For a long time her research was purely fundamental, aimed at gathering knowledge. Meanwhile, businesses have become interested in these fundamental results. The accumulated knowledge from Braakman’s research group about the folding mechanism shows how mutations in the CFTR protein affect the protein itself and how the CFTR protein responds to different substances that were developed as potential medicines. ‘The area of research has grown tremendously in recent years. Effective medicines against cystic fibrosis really are on the horizon,’ she says. In her research Braakman has been trying to find out how a single flaw in the chain of beads can have such far-reaching consequences. She discovered that the most prevalent mutation in the CFTR gene causes problems in a completely different place than where the more common delta-F508 mutation is located. Braakman uses her arms to illustrate how that works. ‘Basically the ends of these chains just flap around,’ she says, waving both of her arms. ‘In a protein that is folded correctly, the ends are quite close to each other, so they can find each other easily. When they come together, the ends intertwine and create a stable entity, like a zipper.’ She folds her hands to illustrate. ‘Because of the genetic delta-F508 error at the base of the zipper, the ends of the zipper seem to end up further away so they cannot find each other. They keep on flapping around. That produces a protein that doesn’t make it through the screening and is broken down.’

One of Braakman’s PhD students seems to have found the exact part of the protein where all the misery begins: the place where the ends start to move too far away from each other.

Out of the blue, a healthy child

That kind of knowledge can lead to the development of medicines, as the American company Vertex proved a few years ago. In 2012 the American drug authority FDA approved for the first time a medicine, called ivacaftor, that addresses the underlying cause of cystic fibrosis and improves the protein. Unfortunately the medicine only works on a fraction of patients. About 1,450 people have cystic fibrosis in the Netherlands. More than eighty per cent of these people have the delta-F508 mutation, which is the most prevalent one worldwide. Only a few patients have the mutation that this medicine targets. Ivacaftor only works with these patients because in their cases the CFTR protein does make it through the screening and nestles itself onto the surface of the cell, only once there it doesn’t do its job. In these patients, the pore is closed, which upsets the salt levels. The medicine takes hold in part of the protein, as a result of which the pore opens after all. ‘It’s a miracle medicine,’ says Braakman. ‘Parents are saying that out of the blue they have a healthy child and have been given their lives back as they don’t have to spend three to five hours a day dealing with the illness anymore. It’s very emotional for them.’

Despite its small-scale application now, Braakman takes a bright view of the treatment’s future. ‘This treatment proves that the method works: that a hereditary disease can be treated at the source with a medicine. This knowledge can be applied on a broader scale, for other diseases as well.’ An article in last May’s *New England Journal of Medicine*, about two medicines that had little effect individually, including ivacaftor, but which were administered together to patients with the common delta-F508 mutation, suggests that this prediction is already coming true. It turns out that the medicines stabilised the protein enough for it to pass the quality control. ‘We were surprised to discover that the medicines did not stabilise the part of the protein where the loose ends were located but another part,’ says Braakman. The drug makes parts of the protein more rigid than the original, and apparently that’s enough to circumvent the screening.’ Braakman’s research shows how healthy CFTR protein folds, what goes wrong in mutant protein and how these new medicines work. She has also demonstrated how ‘chaperone’ proteins assist the folding of the CFTR protein. Based on that, new medicines may well be able to save the faulty folding process in the future after all. So gradually a cure for this disease is on the horizon. ‘Much has been achieved addressing the symptoms, but that will never achieve the quality and duration of life that a healing medicine would,’ says Braakman. ‘It’s good that decades of fundamental research has produced an additional solution.’ ■

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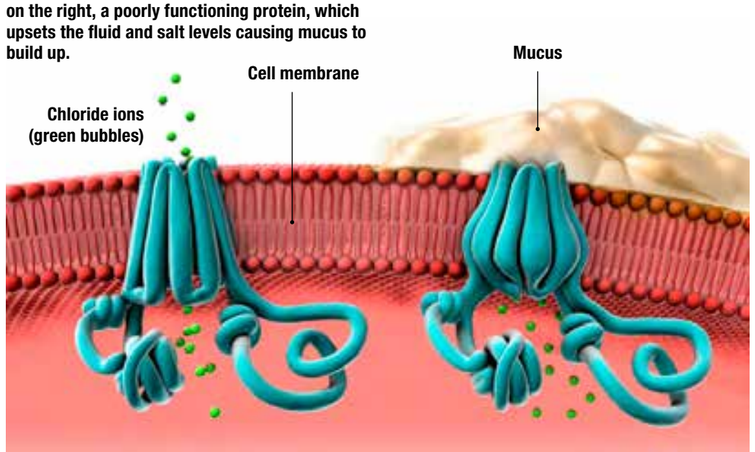
Daily routine

Cystic fibrosis comes in many shapes and sizes, and every patient experiences the disease in a different way, but the most important characteristics for almost everyone are chest tightness and lack of energy. Breathing is often difficult because it’s the lungs that are primarily affected. Patients have to take large amounts of medicine every day to prevent respiratory infections, because bacteria can have serious consequences. These drugs, which are mainly antibiotics, are vaporised and inhaled by means of a special apparatus, all of which takes 15 to 30 minutes. Patients also have to monitor their diet. They have to eat as much as 150 per cent of their usual calorie intake because they get less energy out of their food. That happens because the mucus prevents digestive enzymes from reaching the intestines, as a result of which food is not broken down properly. They also have to move a lot to cough up the mucus, though doing sports is anything but fun when you have breathing difficulties and lack energy.

It’s important to measure the oxygen levels in the blood.

It doesn’t stop there

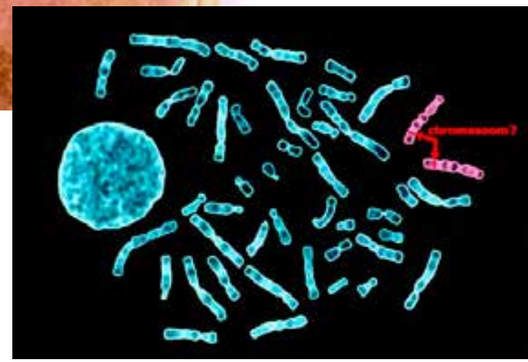
Although cystic fibrosis is a disorder that manifests itself primarily in the lungs, patients have a number of other noteworthy symptoms. More than 95 per cent of male patients appear to be infertile. That’s because the ‘vas deferens’, the duct connecting the testicles to the penis, does not develop in the uterus. The CFTR gene, which is mutated in people with cystic fibrosis, seems to play a key role in this as well. Patients are able to produce sperm, so a pregnancy is possible through interventions such as IVF. Some women also appear to be less fertile. That’s because the layer of mucus in the vagina is too thick. In addition, a special form of diabetes is common among people who have cystic fibrosis.



On the left, a well-functioning CFTR protein, and on the right, a poorly functioning protein, which upsets the fluid and salt levels causing mucus to build up.

◀ **The lungs of a fifteen-year-old girl with cystic fibrosis. The mucus (coloured in red) in the lungs increases the risk of infection.**

▼ **Cystic fibrosis is hereditary. The faulty gene is on the seventh chromosome.**



! MORE INFORMATION

ncfs.nl: site of the Dutch Cystic Fibrosis Foundation.

Wainwright CE, Elborn JS, Ramsey BW et al. (2015): Lumacaftor–ivacaftor in patients with cystic fibrosis homozygous for Phe508del CFTR, *The New England Journal of Medicine*: article about the two medicines that were effective when taken simultaneously.

How to generate renewable energy from plastic

Synthetic sun traps

Nano scientist René Janssen is doing research on plastic solar cells. They are wafer thin and flexible. And they've got great elasticity. 'Technically speaking, solar cells made of plastic can become just as efficient as the current generation of silicon solar cells.' In 2015, Janssen received the NWO Spinoza Prize worth 2.5 million euros.

TEXT: FRANK BEIJEN / PHOTOGRAPHY: ADRIE MOUTHAAN

RENÉ JANSSEN, professor of molecular materials and nanosystems at the Eindhoven University of Technology, received the NWO Spinoza Prize 2015.

Have you already celebrated receiving the prize?
'I was really surprised by the announcement. I'm really very happy with it. Apparently NWO are confident that we'll spend the research money wisely. It's special recognition for the work that our research group has been doing. But I have to keep both feet on the ground. On the evening after the phone call I had to write an assessment report. The day after that was Ascension, and I had to grade 140 exams. But I was very content doing it.'

You're doing research on the way in which plastic solar cells convert light into energy. Why are you so interested in sunlight?
'Actually all energy comes from the sun. Oil and natural gas are essentially solar energy from millions of years ago. They are remnants of plants, and they use sunlight to grow. When you use solar energy directly, you are by-passing a process of formation and storage in the earth that takes millions of years.
Fossil fuels won't run out in our lifetime, but eventually they will. And when you burn them, you're stuck with CO_2 emissions. The sun doesn't play a part in nuclear energy, but we're still not sure what to do with nuclear waste. Our energy supply is our greatest problem, and we need to solve it during this century. That's why it's important to research other ways of producing energy.'

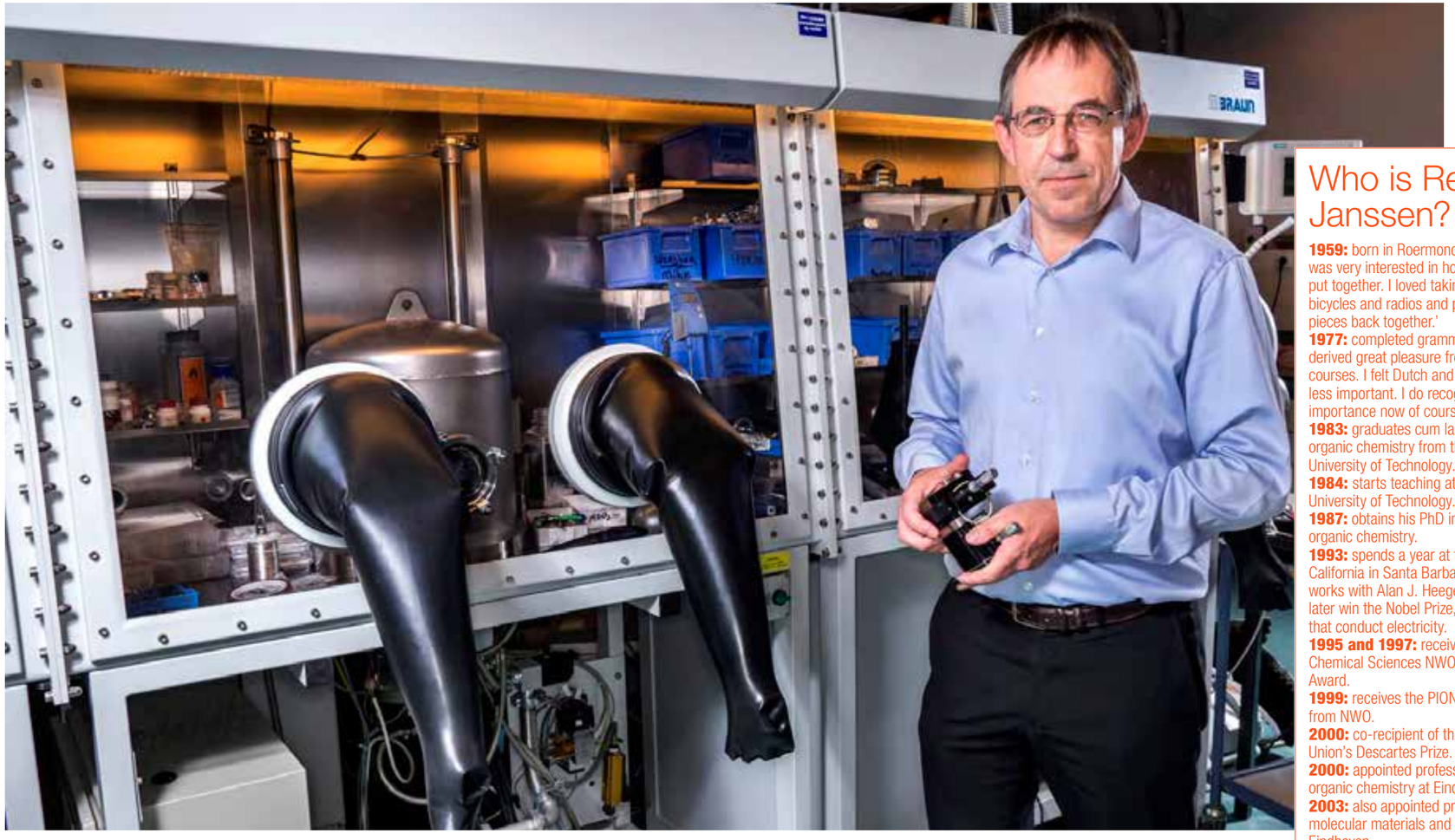
Why would you make solar cells made of plastic?
'The most common solar cells in the past 50 years have been made of silicon. But you can make them out of plastic too. That's not considered a conducting material. It's used to encase copper wires in electricity cables because it insulates so well. Still, it is conductive in certain circumstances. So it is suitable as a material for solar cells. But it's not as simple as just recycling house, garden and kitchen plastic into solar cells. You have to put together the right combination of molecules. That's still very expensive, but ultimately the price will fall.
The required materials are inexhaustible: carbon, hydrogen, nitrogen and oxygen. If we wanted to we could cover the entire planet with plastic solar cells. Another advantage is that they are very thin and flexible, whereas silicon solar cells break when they are bent. Soon we won't need to put flat panels on roofs anymore, but we can cover roof tiles with foil containing plastic solar cells. Or you can make threads with solar cells and use them to weave textiles. For the time being, silicon cells are still more efficient at converting sunlight into energy.'

Plastic solar cells are relatively new. When did you become aware of them?
'In 1993 I worked for a year at the University of California in Santa Barbara. That's where I became aware of the conductive properties of plastic. I was working in Alan J. Heeger's laboratory, where we researched the fundamental properties of plastic. We already knew at the time that plastic can conduct electricity, but we barely knew how that worked. When I returned, we set up a research project with other European researchers that I knew from Santa Barbara. It was like putting a band back together, just like in the *Blues Brothers*.'

When did you move from plastic conductors to plastic solar cells?
'There were signs in the mid-1990s that you could make solar cells from plastic. At first everyone said: "That will never work". When someone tells me something can't be done, I see that as a challenge. In the meantime we've made a lot of progress.'

What is the best solar cell that you've made up till now?
'The best till now, made entirely of plastic, has an efficiency rate of 9.6%. It has a surface area of four by four millimetres. That may seem really small, but actually it's big if you compare it to the thickness. The solar cell is half a micrometre thick (half of a thousandth of a millimetre, ed.). This thin solar cell consists of multiple cells stacked on top of each other, each of which absorbs light from a certain wavelength. That enables you to use light more efficiently. But there are a few complexities involved. The cells are connected in series. If there's a weak one among them, then you'll get low voltage, like a flashlight with a ▶

‘Building is the best way to show that you understand something’



few full batteries and one that’s almost empty. You also have to make sure that you stack the layers that are made up of these cells in the right way. Each layer is applied as a solution containing the right molecules. The solution dries up into a layer that absorbs light, and you add a layer onto that which conducts electricity. The layers have to dry up without dissolving into each other. When you paint a wall, the red paint cannot dissolve into the layer beneath it. The layers have to have the right thickness within a margin of five nanometres.’

But how do you know how it needs to be done?

‘”Understanding” and “the ability to do it” are not so far apart from each other as you may think. James Watt invented the steam engine, but you could ask yourself whether he understood everything about thermodynamics. It’s only once you understand everything about it that you can build a much better steam engine. Building is the best way to show that you understand something. And by building you discover yet other new things.

You have to demonstrate that you can improve every year. If you don’t build in our field, then you won’t know whether or not you are working on the right problem. I really admire people who can make things with their hands. I sometimes wonder whether we appreciate that talent enough. It’s a shame that a lot of industries are vanishing in the Netherlands. That concerns me, because what we are able to make is also the basis of what we can research.’

You play a leading role in international research. Will you manage to maintain your competitive edge?

‘You can’t do this research on your own. The problems are too complex for that. Research groups all over the world are contributing to the solutions. So we progress step by step. Some groups are mainly physics oriented, others focus more on chemistry. I’m a trained chemist myself, but in America I was in a physics research group. There I discovered that an approach through physics was also extremely valuable. But to really make better solar cells you have to combine the two. That’s what we’re trying to do in Eindhoven. We don’t necessarily want to be the best, but we do want to be the first. People always catch up with the best, but if you’re the first to discover something, you’ll always be the first: we were the first to make plastic solar cells from a solution that works with different light wavelengths. We extended the spectrum of absorbed light almost to infrared. We also learned a lot about the properties of the material at the nano-level.’

Will plastic cells replace silicon cells?

‘You won’t hear me saying that plastic solar cells are the solution for the future. We still have to prove that. But science is tasked with finding out whether something is possible and how that something works. We are shooting at a moving target: silicon is also developing fast. When we started with plastic solar cells, we thought achieving a five per cent efficiency rate would have industry queuing up outside our door. Five or six years have passed, and there’s no one at our door. Meanwhile we’ve reached ten per cent efficiency. That’s close to the rate silicon cells used to have. But they’ve reached twenty per cent now. Technically speaking, plastic solar cells can be just as efficient as the current generation of silicon solar cells.’

If the plastic solar cell loses the battle, what’s going to happen to the technology?

‘You can do all kinds of things with the technology. A solar cell is like a camera: it can detect light. So you could use the technology from plastic solar cells in really large cameras, for example. But the flexible cells offer many other options, such as light detectors in plasters and bandages. You could use them to monitor wounds or measure the blood circulation in the skin. Perhaps you can eventually make a cell that you can connect to the optic nerve. Then you could look around with digital technology. I’m not saying it’s possible, but it’s good to dream and get philosophical sometimes.’

Are we going to get all of our energy from the sun?

‘Technically speaking that’s certainly possible. The light that the sun shines onto the earth in a single hour is enough to meet the world’s energy needs for a year. But we have some major steps to take before we can capture light efficiently. The Germans are way ahead when it comes to clean energy. Every farmer there has a roof full of solar panels. On the warmest summer days, half of the total energy supply in Germany comes from solar panels. You need large factories to produce more – and more efficient – solar panels. Each of these factories costs a billion to build. The more factories there are, the lower the price will become. As long as there’s enough demand, more factories will be built.’

What are you planning to do with the money from the Spinoza Prize?

‘We are definitely going to continue with solar cells, because they can really be improved. But I also want to do more research on solar fuels, on ways of storing solar energy as fuel. Solar fuels work with chemical reactions: for example, you can use light to split water into oxygen and hydrogen. You can use the hydrogen later. The chemical reaction resembles photosynthesis. Trees and plants convert CO_2, water and sunlight into sugars and oxygen. But we are already doing it more efficiently than trees and plants.’

Excuse me? More efficiently than plants?

‘Yes. There are many principles we can borrow from nature. Photosynthesis is incredibly complex and clever, but a deciduous tree did not evolve specifically to produce energy. The rate of efficiency is far below one per cent. In fact, the rate of efficiency is so poor that the tree has to go into a kind of hibernation to get through the winter. If the winter lasts too long it is unlikely to survive. So that’s not good enough for us. If we can ensure that we produce more energy during sunny moments than we use, then we can store it for times when we have a shortage of energy.’ ■

frank.beijen@quest.nl

Who is René Janssen?

1959: born in Roermond. ‘As a child I was very interested in how the world is put together. I loved taking apart bicycles and radios and putting all their pieces back together.’
1977: completed grammar school. ‘I derived great pleasure from the science courses. I felt Dutch and English were less important. I do recognise their importance now of course.’
1983: graduates cum laude in physical organic chemistry from the Eindhoven University of Technology.
1984: starts teaching at the Eindhoven University of Technology.
1987: obtains his PhD in physical organic chemistry.
1993: spends a year at the University of California in Santa Barbara. There he works with Alan J. Heeger, who would later win the Nobel Prize, on plastics that conduct electricity.
1995 and 1997: receives the Chemical Sciences NWO Young Chemist Award.
1999: receives the PIONEER Award from NWO.
2000: co-recipient of the European Union’s Descartes Prize.
2000: appointed professor of physical organic chemistry at Eindhoven.
2003: also appointed professor of molecular materials and nanosystems at Eindhoven.
2006: receives Chemical Sciences TOP grant from NWO.
2011: becomes member of the Royal Netherlands Academy of Arts and Sciences.
2013: becomes distinguished university professor at the Eindhoven University of Technology.
2013: receives an Advanced Grant from the European research organisation ERC.

The legends and fairy tales lurking in the Dutch countryside

Story hunting among cows

Cycle or walk through the stunning Dutch landscape, all the while listening to exciting stories about witches and ghosts – it's all possible with 'Sagenjager.nl', or LegendTracker. This website takes you on a tour of old folktales. Experiment NL decided to put the site to the test and went fairy-tale hunting through the wetlands of Waterland in North Holland.

TEXT: ANOUK BROERSMA

The Aandammer Bridge is situated in a lovely landscape full of small canals, reed beds and meadows with peacefully ruminating cows. It seems calm, but appearances can be deceiving – if we are to believe the stories. Dancing black cats were once seen on this bridge. Perhaps they were witches who had changed shape. Once a farmer in his boat only just escaped from the jaws of 'a dog with black curly fur and fiery eyes', which had jumped him from the bridge railing. This is one of the locations that I came across when I took the LegendTracker walking tour. The Sagenjager.nl website was launched in the spring of 2015 and provides folktale routes in Waterland, a region with tourist attractions such as Marken and Volendam. Armed with a smartphone, you can follow one of the marked trails or use the map to find your own way around. The website's navigation system makes sure that you will never get lost among the Dutch cows. On the way you can read or listen to stories from the area: legends and fairy tales about ghosts, witches, sorcerers and mermaids, but also jokes and urban legends.

The benefits of giving birth

Sagenjager.nl is a project of the Meertens Institute, which conducts research on Dutch language and culture. The project is run by Theo Meder, who researches folktales, and NWO assisted with funding in the framework of the NWO programme CATCH, Continuous Access to Cultural Heritage.
The aim of CATCH is to make cultural heritage, such as stories from our grandmothers' time, available digitally. Meder had already collected many stories in the Meertens Institute's Dutch Folktale Database, but he was still looking for a way to let more people get enjoyment out of it. That's how the idea to link stories to cycling and walking came about. Waterland was the perfect place to start. Great stories are there for the taking in that area, thanks to a single industrious story collector: Cornelis Bakker. Bakker was a doctor in Waterland in the late-1800s. Nikkie Herberigs, who compiled the LegendTracker routes as a freelance art historian, tells the story: 'His work took him to many different places in the region, to help with childbirth, for example. That could take a long time sometimes. In the meantime, Bakker would ask the family about the folktales they knew. Once the stories started to flow, he would write them down.' He would then send his notes to Gerrit Jacob Boekenoogen, a linguist from Leiden who was recording folktales in books around the same time.

The Aandammer Bridge is one of the locations on the LegendTracker walking tour. The bridge is locally famous for its dancing black cats and aggressive dog.

Grietje, clairvoyant

If it weren't for Bakker's urge to collect, we would never have so many stories on paper from Waterland. Indeed, Herberigs even dedicated a cycling route to the doctor, the Bakker Route. I chose the walking route, and on an overcast Friday afternoon found myself standing in front of Cornelis Bakker's house, which is the starting point in the village of Broek in Waterland. Nowadays the wooden, mint-green painted dwelling is a regular residential house, but in those days Bakker had his medical practice and pharmacy here. The route leads out of the village and along the water – where aquatic monsters like the Okkerman will drag you into the water if you get too close – and down Dokter C. Bakkerstraat. Once in the countryside, I walked past meadows with cows, sheep and horses. Herons stared at me from the reeds, and ducks and swans floated in the many ditches.
These were the kinds of small canals that Cornelis Bakker travelled on to make house calls and come back with new stories. Meder entered all of these stories into the folktale database, as well as a number of other Waterland stories from other sources. Herberigs then had the difficult task of making a selection for the LegendTracker. She focused on two issues: whether there were enough different kinds of stories (see 'Identify the story' box) and whether they were well distributed throughout the landscape. 'Some stories clearly feature a location, like the Aandammer Bridge. People are even mentioned by their full name in the stories sometimes.' One example is Grietje Holleman, who lived in the region from 1823 to 1894 and was known as a witch. 'She fed that rumour as well, by pretending to be clairvoyant,' Herberigs says. The lady was renowned for being able to foresee accidents and even deaths. Her own death oc- ▶

The stories say something about the culture of gossiping at the time

Cornelis Bakker, doctor and story collector, with wife and daughter.

curred on a road near Monnickendam. Whether Grietje possessed the skills of prediction is doubtful, but she did really exist. The village doctor even knew her. 'Because this concerns real people,' says Herberigs, 'these stories paint a picture of the time. They say something about the culture of gossiping. People were ostracised from society because they were considered to be a witch or sorcerer. It's confronting but also makes for interesting reading.'

Goblin in the night

The stories were corny sometimes and needed a tiny bit of rephrasing. But Herberigs tried not to rewrite too much. 'I liked to let the spirit of the times filter through the language.' Anyone interested in completely immersing themselves in the spirit of the times can click on a link in any story on Sagenjager.nl that will take them to the original text in the folk-tale database.

Herberigs added annotations to many of the stories. About halfway down the Bakker Route, there's the story of someone who woke up at night with the feeling that a cat-like creature was creeping over his body and sitting on his throat. In the audio clip you hear a possible explanation for this event when the story ends: sleep paralysis. It's normal for the body's muscles to stiffen during REM sleep, but sometimes people still feel the stiffness when they wake up, which can result in a suffocating feeling and sometimes even hallucinations. People used to think that it was a nightmare ('night mare'). They weren't referring to a dream but to a creature: a 'mare' or goblin.

Illustration by German painter Hans Baldung (1485-1545) depicting a prototypical witch.

Front door is death door

Waterland was the first LegendTracker route. Another one followed in August, around Oostermeer in Friesland. A fanatic collector lived there too, the writer Dam Jaarsma. Unlike Bakker he didn't have a boat, but instead cycled around the region to visit storytellers in the 1960s and 1970s. The cycling and walking route for the LegendTracker is based on the stories that he gathered. The idea is that bit by bit more storytelling routes in the Netherlands will appear in the LegendTracker, based on the stories that have ended up in the Meertens Institute's Folktale Database.

After walking for ten kilometres, the Bakker Route brought me back to Broek in Waterland. Right at the end, I learned that the front doors of the wooden houses are 'death doors'. In the old days, only the bride was allowed through the door and into the house on her wedding day. After that, everyone walked to the back of the house, and the front door was only opened to carry residents outside to their funeral. So you see, not every gruesome story needs a witch or a ghost as protagonist. ■

redactie@quest.nl

Identify the story

Folktales exist in all shapes and sizes. How do they differ?

FAIRY TALES: start with the famous words 'Once upon a time…' and usually have a happy end. When or where the tale takes place remains shrouded in mystery.

LEGENDS: short stories that do mention a time and place. Supernatural beings often play an important role: witches, ghosts, sorcerers, gnomes and devils. Legends were often told as if they had really happened. The storyteller or a close acquaintance has experienced the events him or herself.

SAINT'S LEGENDS: Christian stories that take place mainly in Catholic areas. The protagonists are often saints or holy objects: a weeping statue of the Virgin Mary or an indestructible bible.

JOKES: short stories with a joke at the end. The precursors to the joke were longer, more farcical stories.

URBAN LEGENDS: the modern version of legends. Urban legends involve something strange or creepy that has genuinely happened to a friend of a friend of the storyteller. An example is the old American lady who tried to dry her dog (or cat) in the microwave.

! MORE INFORMATION

sagenjager.nl: check out the routes and their stories.
verhalenbank.nl: browse the entire collection of Dutch fairy tales, legends, jokes, etc. here

Too hot to handle

Besides being a spectacular feast for the eyes, lightning has always been a physical phenomenon that inspires awe. Indeed, recent research shows that powerful lightning can even generate antimatter, particles usually associated with distant galaxies and particle accelerators. So how is this possible? A lightning bolt's discharge can be so violent locally that free electrons reach an extremely high energy level. When these electrons collide with air molecules, they can produce antimatter. The antiparticles that are generated, called positrons, are the exact opposite of ordinary electrons. Former PhD student Christoph Köhn from Centrum Wiskunde & Informatica (CWI) in Amsterdam created a model of the complex process that generates antimatter.

In 2011 a NASA satellite registered antimatter above lightning for the first time. We've known for two decades now that lightning flashes also generate X-ray and gamma radiation. But physicists are still debating whether this radiation poses a threat to human beings. Usually its energy is absorbed in the air. As long as a lightning bolt develops far away, there is little to worry about. But there is a danger for humans who are in the vicinity of the discharge. Though you're more likely to get hit by lightning.

IN BRIEF

Criminals like familiar territory. They're just like people.

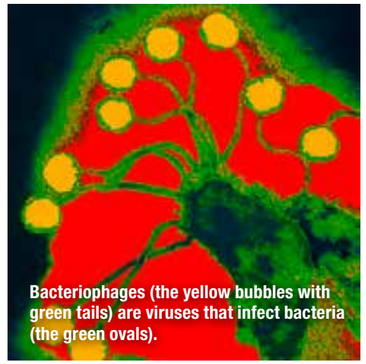
3D painting

Sometimes a beautiful painting wants to make you crawl right into it. You can kind of do that with industrial designer Maarten Wijntjes' 'synopter'. He developed a modern version of the apparatus, which was patented in 1907 and plays with how you experience depth, at the Delft University of Technology. Usually each of your eyes see things slightly differently because they are positioned next to each other. This 'stereo vision' is what makes the world three-dimensional. The synopter presents both eyes with exactly the same image. As a result, your brain has to use the clues in the image, such as objects whose size you know, to gauge depth. The reason why you suddenly see that amazing Rembrandt in 3D is because the clues in the paintings are just as good as the ones we get in real life.

Visiting the Rijksmuseum with a synopter. Suddenly you're no longer standing in front of *The Night Watch* but inside it.

Healthy memory

It's well known that elephants have good memories. But bacteria are pretty sharp too! Microbiologist Stan Brouns from Wageningen University discovered that unicellular organisms have a memory for pathogens, such as viruses. The bacteria store pieces of DNA from the virus. Then they produce proteins that use the stored genetic code to search and destroy the virus's DNA. That's when the race with the viruses begins, as they change their DNA to dodge the bacteria's immune system. That's challenging, because the virus has to adapt more than a third of its DNA before the bacteria ceases to recognise it. The special properties of the bacteria protein will be applied in medicine in the future to repair defects in human DNA to combat diseases.



Bacteriophages (the yellow bubbles with green tails) are viruses that infect bacteria (the green ovals).

Back to the scene of the crime

It seems that criminals are also afflicted by something as domestic as homesickness. Research conducted by criminologist Marre Lammers and colleagues from the Netherlands Institute for the Study of Crime and Law Enforcement demonstrates that criminals often strike in neighbourhoods where they have operated before, especially if that was recently and even if they were arrested at the time. The criminologist studied the police records of thousands of criminals in The Hague, such as burglars and people who commit violent crimes. Lammers will interview offenders in follow-up research, in which she also hopes to obtain information about offences for which they were never caught. This new data will reveal whether criminals have other favourite areas to operate in, for example because they attend school there or are employed in these neighbourhoods.

Perfect organ

When there are few donor organs available, it's important to take good care of the ones that you do have. With that idea in mind, in 1999 Gerhard Rakhorst, professor emeritus at the University of Groningen, began his research into machines that can keep organs healthy until they are used for a transplant. That led to the founding of a company called Organ Assist in 2004. The first machines developed by the company were meant to conserve livers and kidneys to the highest standard. A year and a half ago the company also developed a machine for lungs. This is how it works: you connect the organ to a small pump that pushes an oxygenated fluid through it, and a thermostat ensures a perfect temperature. Organ Assist is now focusing on the pancreas and the heart. Their aim is to develop machines that will conserve all transplant organs.

A machine for conserving donor lungs. The better they're conserved, the more useful they will be.

An impression of a neutron star (left) feeding itself on a neighbouring star.

Record explosion sighted

Astronomers find neutron stars irresistible because they're the most compact objects in the universe that can still emit light. Jean in 't Zand from SRON Netherlands Institute for Space Research is searching for specimens that have another star nearby. Those stars that have a companion nearby will be slowly consumed by the neutron star. The accumulation of 'stardust' creates nuclear explosions on the neutron star, which releases massive amounts of energy. The more matter can accumulate, the more violent the explosion. If it's a big enough bang, it can withstand the immense gravity of the neutron star and become a true explosion. In 't Zand has registered one of these mega explosions. What's more, this explosion expanded with one third the speed of light. The fastest ever recorded.

Sweaty feet get their odour from thiols too.

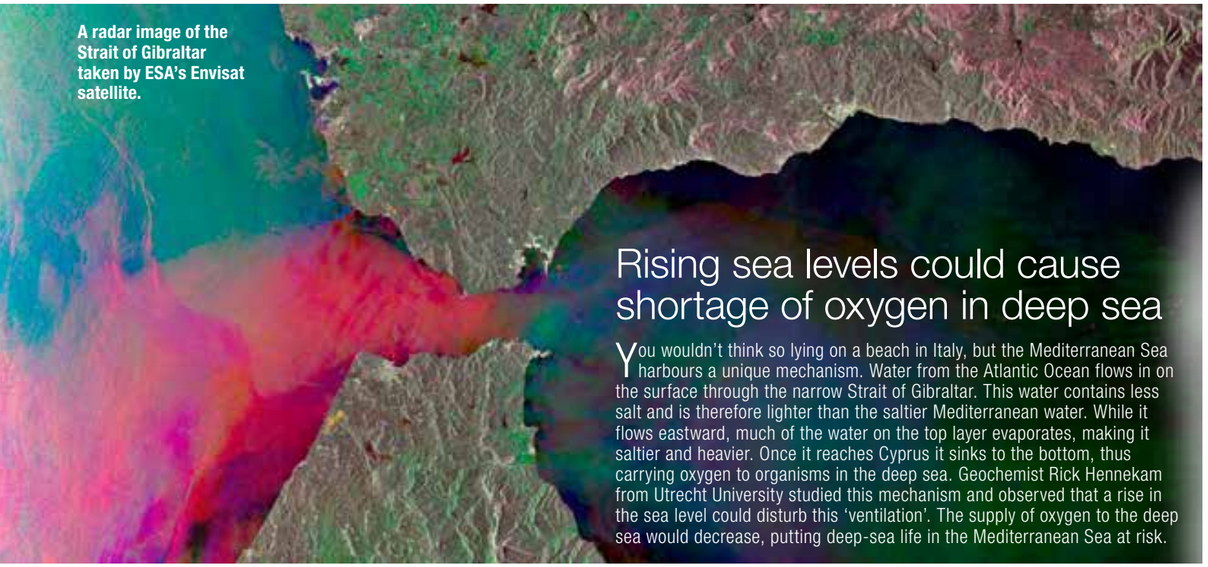
Odourless discovery

Sometimes discoveries fall out of the sky for scientists. It happened to bioengineer Marco Fraaije from the University of Groningen. Fraaije was working on the oxidation of alcohol compounds: he made molecules from the family of aromatic alcohols by using enzymes. The products of these reactions can be used to produce polymers and plastics. On a hunch he discovered that the enzyme he was using for the oxidation reaction also worked with thiol molecules. Thiols strongly resemble alcohols, but they have a sulphur atom instead of an oxygen atom. And they smell: skunks use thiols, but thiols also add taste to coffee, wine and popcorn. Fraaije's oxidation reaction makes the smell of the thiols disappear. And so his research could lead to a spray that combats foul smells.

Women (and children) working in the Parc National de la Pendjari in Benin.

Fertile traditions

Women in West Africa don't have it easy. They live in a society where fertility is of paramount importance, but they have little opportunity to receive health care or information about health. Medicinal plants provide a solution to this problem. Ethnobotanist Alexandra M. Towns obtained her doctorate at Leiden University for researching the plants that women in Gabon and Benin use for health purposes. She discovered that these women need care for their menstruation and fertility. Towns saw that African women make tea from the roots of the fig-like *Sarcocephalus latifolius* to ease menstrual pain. The PhD student believes that our doctors should give these traditions more acknowledgement, so that relief efforts for immigrants, for example, can proceed more smoothly.



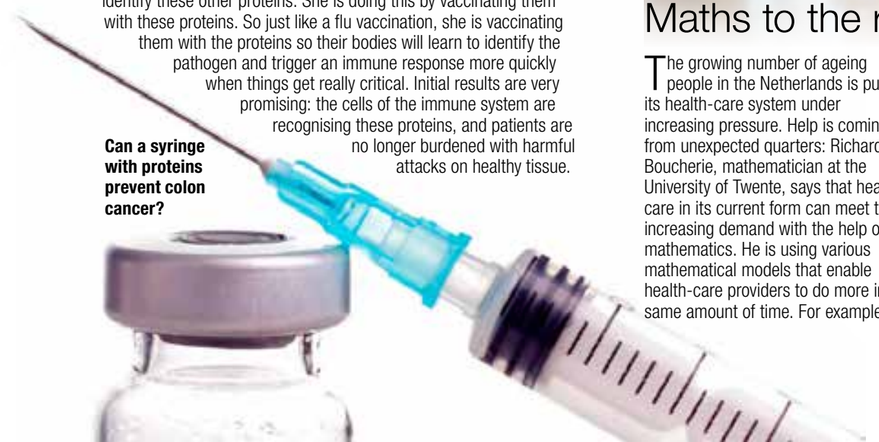
A radar image of the Strait of Gibraltar taken by ESA's Envisat satellite.

Rising sea levels could cause shortage of oxygen in deep sea

You wouldn't think so lying on a beach in Italy, but the Mediterranean Sea harbours a unique mechanism. Water from the Atlantic Ocean flows in on the surface through the narrow Strait of Gibraltar. This water contains less salt and is therefore lighter than the saltier Mediterranean water. While it flows eastward, much of the water on the top layer evaporates, making it saltier and heavier. Once it reaches Cyprus it sinks to the bottom, thus carrying oxygen to organisms in the deep sea. Geochemist Rick Hennekam from Utrecht University studied this mechanism and observed that a rise in the sea level could disturb this 'ventilation'. The supply of oxygen to the deep sea would decrease, putting deep-sea life in the Mediterranean Sea at risk.

Vaccine against cancer

How can we use our immune system to fight cancer? That's precisely what immunologist Jolanda de Vries from Radboud University Nijmegen is trying to find out. She is studying patients with Lynch Syndrome, who have a specific DNA mutation. This mutation causes proteins to be produced in their bodies with a slightly different structure, which increases their chances of getting a certain kind of colon cancer. De Vries is trying to teach the immune systems of people with the Lynch mutation, but who are still cancer-free, to identify these other proteins. She is doing this by vaccinating them with these proteins. So just like a flu vaccination, she is vaccinating them with the proteins so their bodies will learn to identify the pathogen and trigger an immune response more quickly when things get really critical. Initial results are very promising: the cells of the immune system are recognising these proteins, and patients are no longer burdened with harmful attacks on healthy tissue.



Can a syringe with proteins prevent colon cancer?

Maths to the rescue

The growing number of ageing people in the Netherlands is putting its health-care system under increasing pressure. Help is coming from unexpected quarters: Richard Boucherie, mathematician at the University of Twente, says that health care in its current form can meet the increasing demand with the help of mathematics. He is using various mathematical models that enable health-care providers to do more in the same amount of time. For example, Boucherie developed a model with a home-care organisation that optimises home-care providers' scheduling. The model mathematically processed the route to clients' homes together with the sequence of clients. Health-care professionals can now spend more time on giving more targeted care. Boucherie's work is also helping to ease work pressure on nursing wards, plan operations and find the fastest route when transporting the elderly and disabled persons, for example.

High-flyers in the world of science

NWO IS INVESTING IN SCIENTIFIC TALENT. IT AWARDS GRANTS THROUGH SPECIAL PROGRAMMES TO BOTH YOUNG AND EXPERIENCED SCIENTISTS SO THEY CAN SET UP THEIR OWN RESEARCH.

TEXT: ANTJE VELD / PHOTOGRAPHY: ADRIE MOUTHAAN

Never distracted

Who? Roshan Cools (40), professor of cognitive neuropsychiatry at Radboudumc. **Funding?** A Vici worth up to 1.5 million euros that enables senior researchers to set up their own research group.

What kind of research do you do?
'I focus on the role of neurotransmitters such as dopamine and serotonin in our brain function, cognition and behaviour. I intend to use the Vici funds to research the beneficial and detrimental effects of dopamine-enhancing substances, such as Ritalin (methylphenidate), on healthy people. An increasing number of people seem to be using these substances to enhance their performance. But we still know little about the effects of methylphenidate on cognition and the brain. It helps some to become less easily distracted, but others perform worse. In fact, being distracted is not necessarily a bad thing. If a fire breaks out while you're studying, for example. Forbidding yourself from ever becoming distracted and forcing yourself to always focus on a single task can also have negative consequences for your brain functions that are important for creative thinking.'

Which research has opened new doors for you?
'The discovery that the medication given to patients with Parkinson's to help them move better also causes impulsive behaviour. A number of patients on the medication have developed impulse control disorders, such as gambling addiction or hypersexuality. Knowing that stimulating certain specific areas of the brain can also cause behavioural disorders is what drives many of my questions.'

What inspired you to go into this field?
'I developed an interest in the brain early on. When I heard about the phenomenon of "hallucinations" as a child, I already wondered how something like that works, how the brain can produce something that's not there. And of course my father, who was a professor of psychoneuropharmacology, was an important source of inspiration for me.'

Roshan Cools: 'Forbidding yourself from ever becoming distracted can have negative consequences for brain functions that are important for creative thinking.'

What's in an egg?

Who? Oscar Vedder (35), postdoctoral researcher of evolutionary ecology at the University of Groningen. **Funding?** A Veni worth up to 250,000 euros that enables recently graduated PhD researchers to develop their research ideas.

What kind of research do you do?
'I do research on the effects of varying conditions in which common terns are raised. The common tern is a long-living bird species found in Europe, among other places. I study the effects that the conditions around the time of a bird's birth have on the rest of its life. Differences between individuals arise, for example, from the fact that one tern is raised in a year when food is abundant, while another may not. But there are differences within a nest as well. Terns usually lay three eggs. They hatch one by one. When food is scarce, the tern from the third egg will be at a disadvantage. I also examine whether the terns in the egg have already adapted to their future situation, for example by allowing a third egg to artificially hatch first and then observe whether the hatchling behaves differently.'

What is the most important discovery in your field in the past five years?
'The discovery that telomere length tells us something about life expectancy. Telomeres are small sections of DNA at the end of a chromosome. They protect cells against ageing, but they become shorter as a result of cell division or stress, for example. Recent studies by researchers in Groningen and in the UK revealed that the length of telomeres provide an indication of the damage that has occurred during a lifetime. I use that knowledge in my research too.'

What inspired you to get into this field?
'I was already interested in nature at a young age. As a child, I used to go bird watching regularly, and I was a member of a youth association for nature and environmental studies. I'm also fascinated by evolutionary questions about life. I would like to explain why the things that we see around us are the way they are.'

Oscar Vedder: 'Telomere length tells us something about life expectancy. I use this knowledge in my research.'

Shuffling atoms

Who? Petra de Jongh (44), professor of inorganic nanomaterials at Utrecht University. **Funding?** An Aspasia grant (100,000 euros), which is linked to a Vidi or Vici, to help more female scientists progress to associate and full professorships.

What kind of research do you do?
'I do research on catalysts. Those are materials that convert one thing into another. Such as an exhaust catalyst that converts toxic combustion products into substances that are not harmful. More than 85 per cent of the materials that we know are made with catalysts. It's usually based on a metal, such as iron or copper, in powder form. You need fine particles to shuffle around the atoms of a gas or liquid molecule in order to create the material that you want. But these catalysts only last for a few years, essentially because the powder particles tend to increasingly clot together over time. I'm researching how particles move at the nano-level, how they grow and how we can extend the life of catalysts.'

What is the most important discovery in your field in the past five years?
'The development of analysis techniques such as electron microscopes. I wouldn't have been able to do this research twenty years ago, because I simply wouldn't have been able to see. I look at materials at the nanometre level (a millionth of the thickness of a hair). That's possible now under the right circumstances: at high temperatures, with the addition of a gas or liquid.'

What would it take to get more women working in your field?
'I've never experienced opposition in my direct environment, on the contrary, but the fact is that only fifteen per cent of professors in the Netherlands are female. But at the student and PhD level it's half. There are enough enthusiastic and intelligent women, but nevertheless there are people with prejudices. You could use a quota. But as a woman, you'd like to be hired because you're a good professor.'

Petra de Jongh: 'More than 85 per cent of the materials that we know were made with a catalyst.'

Less violence

Who? Bram Büscher (37), professor of sociology of development and change at Wageningen University. **Funding?** A Vidi grant worth up to 800,000 euros that enables experienced researchers to set up their own line of research.

What kind of research do you do?
'I'm interested in the changing relationship between people and nature, especially in developing societies suffering from acute inequality, such as in southern Africa. I study how the relationship between people develops under these circumstances and I try to look at them from a different vantage point by investigating specific situations in detail. An example of a situation that I studied is the collaborative effort between various parties in cross-border nature reserves in southern Africa.'

What are you going to do with the Vidi money?
'In the global context of the increasing pressure on ecosystems and biodiversity, I'm going to study how this pressure is increasingly leading to spirals of violence around nature areas. Poaching is a huge threat to nature. In South Africa, rhinoceroses are being slaughtered in large numbers. Conservation organisations are responding in kind by sending in the army. That's how they find themselves in a spiral of violence that is rapidly intensifying. I am going to do research in three countries – Brazil, Indonesia and South Africa – to examine what the recurring elements are in the genesis of these spirals of violence, in the hope that we can eventually break through them.'

Who will notice your research?
'I hope we all will, because the current pressure on nature and its social impact concern everyone. But my initial aim is for my research to benefit authorities and nature reserve organisations. I also want to make policy recommendations to organisations such as the UN and the World Conservation Union. In addition, we will reserve some of the money to run workshops in conflict areas, in order to use knowledge from the project to break through the spiral of violence.'

Bram Büscher: 'I'm hoping that authorities and nature reserve organisations that are struggling with violence related to poaching will benefit from my research.'

How are bottom-dwellers responding to the construction of the Sand Motor?

The sands of time

Twenty kilometres off the coast, ships pumped sand from the sea floor, which was used to construct a massive peninsula near Kijkduin in 2011: the Sand Motor. What do the animals that live in the sand at the bottom of the sea think of it?

TEXT: PAUL SERAIL

The two-kilometre-long Sand Motor protects the coastline.

Comfort zone

If you were to walk from the beach deeper and deeper into the sea, holding your breath until you were ten metres under the surface of the water, then you would keep moving through the habitat of different animals. Because some animals like shallow water, while others prefer to be several metres underwater. The waves have an impact on this, according to Simeon Moons, ecologist at NIOZ, the Royal Netherlands Institute for Sea Research. The swells are felt the first few metres below sea level, and not all animals like to be rocked back and forth. Fine sand may drift down to the bottom in places where the surge has less of an impact, where amphipods like to dig themselves in with their rear legs, for example. So every animal has its favourite zone. ‘The building of the Sand Motor left a barren area behind underwater,’ Moons explains. Soon all kinds of animal species came to have a look. ‘In the first phase, depth zonation and grain size don’t matter too much yet.’ There are plenty of places for the animals to occupy, and they haven’t discovered their favourite zone yet. ‘After three years, the balance was almost restored and most bottom-dwellers had claimed their favourite places.’

The wind and the sea affect the coastline, but animals play a part too

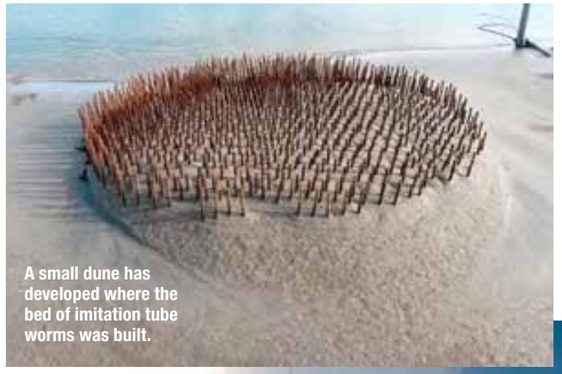
We're standing up to our ankles in the North Sea at Kijkduin, near The Hague. 'When there's a black spot in the seabed, there's usually an animal there,' Simeon Moons points out. He's a marine ecologist at NIOZ, the Royal Netherlands Institute for Sea Research in Yerseke. After a quick look, he finds a black spot. Moons reaches into the water and pushes his fingers beneath the spot to dig up the black sand. He lets the sand trickle through his fingers, and sure enough, he has found a shellfish. The ecologist is studying the animals that live on the seabed here for his research. He's focusing in particular on the life around the Sand Motor, a peninsula constructed in 2011 by pumping sand from the depths onto the coastline near Kijkduin. Moons wanted to find out how bottom-dwellers would respond to this. Will they do better here or worse than in places where there is no Sand Motor?

The coast in context

The Dutch coastline is in constant flux. Waves pound against it day in and day out. Currents of water drag sand to and fro, and the wind constantly picks up grains of sand and deposits them again further on. The result is a coast that's more or less moving inland. And seawater sometimes flows inland too, especially during stormy weather. But people aren't too fond of flooding, so dunes and dikes were built to keep the land dry. In 1990 the minister of Transport, Public Works and Water Management decided that the coastline had to remain as it was at that moment. The only problem was that waves, wind and currents tend to ignore rules. Storms were the greatest danger. 'The sea can suddenly transport a huge amount of sand during a storm,' says Moons. That's why the coastline needs to be maintained. 'We've been replenishing sand since the late 1970s,' Moons begins. He explains that there are three options: sand can be used to raise and widen the dunes, raise and widen the beaches, or the third option is to pour sand underwater. 'Shoreface nourishment is what you mostly see these days,' says Moons. It increases the volume of sand in front of the coast and that protects us against storms. 'If you deposit extra sand in front of the coast, then enough will remain if a storm washes part of it away.' Unfortunately sand nourishment is a bit like filling a bucket that's full of holes. The wind and the sea are continuously carrying away huge loads of sand. 'The coast here at Kijkduin,' says Moons, 'needs to be replenished every five years.'

The Ministry of Infrastructure and the Environment knew there had to be a better way. Something that preferably cost less and was better for the environment. 'When you replenish the dunes, you destroy part of them and therefore part of nature too,' says Moons. Money is an issue too. Beach and dune nourishment requires ships to transport the sand, which then needs to be brought on shore. That's done through pipelines, after which bulldozers distribute the sand. Shoreface nourishment is cheaper. Put simply, a ship arrives and dumps its load at a given place. The disadvantage, of course, is that it kills the bottom-dwellers there. Every five years, all living things get a load of sand dumped on them. The newly conceived fourth option, the Sand Motor, used a huge amount of sand in a single place, ten times as much as would have been needed for shoreface nourishment. It's supposed to protect the coast from the Hook of Holland to Scheveningen for twenty years. 'The Sand Motor is shaped like a hook,' Moons says as he draws it on a piece of paper. 'The peninsula is more than two kilometres long and extends a kilometre into the sea.' It's then up to nature to do the hard work. Most of the sand is expected to gradually shift towards Scheveningen. A small part of it, on the other hand, will move south, towards the Hook of Holland. So what do bottom-dwellers prefer: a huge amount of sand in one place once every twenty years, or a smaller load everywhere along the coast every five years?

Sediment sample from the Sand Motor.



A small dune has developed where the bed of imitation tube worms was built.

The imitation tube worms are put into place.

Excavated tube worms and Baltic clams from the lagoon.

Animals rising from the depths

We still don't know if the Sand Motor is doing what it's supposed to be doing because it's a pilot project. Various PhD students are studying it. Evaluations are scheduled for 2016 and 2021. Moons is one of the ecologists researching the impact on nature. The Ministry of Infrastructure and the Environment is taking samples at different places around the Sand Motor. First annually, now every two years. Moons is also taking samples from other locations along the coast, in order to discover what's living on the sea floor. There are places at the Sand Motor where strong currents have free reign. A great deal of sand gets washed away there in a short amount of time. 'The sea floor is steep and inhospitable. Few animals live there.' But striking species have settled in other places. Moons digs up another black spot. 'You know this one,' he says. He holds a razor clam in his hand, also known as Ensis. 'You would normally only find these animals at greater depths,' explains Moons. 'They're not bothered by the waves there, and that's the way these creatures like it.' So what's this razor clam doing in ankle-deep water? 'We're standing in a lagoon,' Moons points out. The water is largely cut off from the sea. You don't notice the waves here, which explains why this species can be found just two metres from the beach.

▶ Razor clam with foot visible at bottom.

Worms that capture sand

As it turns out, the Sand Motor provides suitable places for a wide range of species, because the circumstances in various places around the peninsula differ slightly from each other. There's always a ▶

Bottom-dwellers

So what exactly lives on the sea floor around the Sand Motor? Here are five of the bottom-dwellers.

• When counting the common shore crab's legs, we include the claws. So it's a decapod. When a crab burrows, sand whirls upward. The current picks it up and carries it away. That's how animals, albeit on a minor scale, influence the distribution of sand around the Sand Motor. Crabs are like garbage collectors: they clean up all the dead organisms.

• The sandgaper got its name from the fact that its valves don't close perfectly. So they're always somewhat open, gaping. This shellfish lives mainly in estuaries and areas around estuaries. You rarely saw these bivalves along the coast of North or South Holland in the past, but it feels right at home in the calm waters around the Sand Motor.

• Sand mason worms build a tube made from sand and pieces of shell in which they live. The tubes stick out of the sea floor like rods. Sand can pile up in between them, but nutrients also settle here, so that other bottom-dwellers like to hang around groups of sand mason worms. They live in abundance in the deep water by the coast, but they also live in shallow parts of the Sand Motor.

• Once the razor clam has buried itself, it helps to keep sea sand in its place. When it digs, it uses its so-called 'foot'. The foot extends out of the shell and wriggles into the sea floor. There the foot inflates and anchors itself. Then the foot pulls the shell downward. When swimming, the razor clam uses its shell, however. The animal expels water from the shell, shooting itself forward.

• Flatfish, such as plaice, are so well camouflaged that they're almost invisible when lying on the sea floor. They burrow to hide themselves even more effectively. Incidentally, their belly is white. And the fish larvae still swim upright in their first weeks.

Animals from a single sample. They have been coloured red so that they are easier to recognize.

The sea floor is full of creatures

The Sand Motor's sand was sprayed onto the land from boats.

▶ creature out there that will feel at home. But the razor clam that Moons just dug up is interesting for another reason. 'If I release it, it will immediately dig itself in again,' Moons predicts. And indeed, the shellfish floats down to the bottom, straightens up and disappears like a pile into the ground until all that remains is a flaccid arm sticking out of the sand, the 'siphon' that it uses to filter food from the water. 'What the designers of the Sand Motor didn't take into account is that organisms can also have an impact on the sea floor,' says Moons. He calls crabs and plaice 'bioturbators', for example, because they cause sand to whirl up when they burrow. It may land further down somewhere. A 'bioirrigator', for example, is a worm or shellfish that lives in the sea floor and pumps water through it to obtain food and oxygen. And then there's the 'biostabiliser', an animal that keeps sand in its place. Moons cites the tube worm as an example. It uses mucus to build a solid tube around its body, made of sand and pieces of shell, that sticks up vertically out of the sea floor. When the razor clam sits in the sea floor, it too is a biostabiliser. But how do these creatures affect the movement of sand? Moons has mimicked the tube worms by creating a bed of nails with metal pins. He then studied the movement of sand around the imitation worms. 'If there's only one tube, then erosion occurs,' the ecologist explains. The water that flows around the tube takes the sand that's there with it. 'A bed of tubes captures the sand, however, and creates a small dune underwater.' Moons hopes to study the impact of living animals in a racetrack flume in his lab. Their impact will be much less noticeable than that of the wind or the sea, Moons admits, but nevertheless these bottom-dwellers do help to shape the coast.

The coast is calm

Back to the big question: what's better, a huge amount of sand suddenly in one place, like the Sand Motor, or sand everywhere every five years? 'If the sand spreads in a natural way then you'll have a more natural system,' Moons expects. Now that the Sand Motor is there, most of the coastline between the Hook of Holland and Scheveningen is no longer being disturbed by frequent nourishment. Sand calmly makes its way there, taken by the currents. The Sand Motor itself has good news for us too. 'There was greater biodiversity around the Sand Motor two years after it had been built than there was in the area in 2010,' Moons says. Indeed, he also analysed samples from 2010, when the peninsula had not been built yet. So more species can be found here since the Sand Motor was built. Moreover, he adds, the numbers per species have also increased, though Moons suspects this effect to be temporary. For now, the conclusion is that dumping loads of sand to build the Sand Motor caused a major disturbance, but nature has recovered quickly and is doing well now. So from a biological perspective, this alternative seems to be a step forward compared to the 'old-fashioned' regular nourishment. ■

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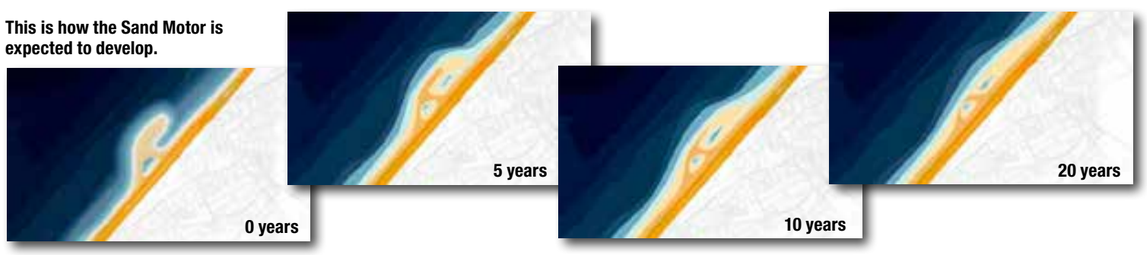
! MORE INFORMATION

dezandmotor.nl: how to get to the Sand Motor, whether it's warm enough to swim and lots of other information.

This is how the Sand Motor is expected to develop.



Baby vitamins

Vitamins are also crucial for the very youngest among us, including unborn babies. Research by Reina Mebius from the VU University Medical Center shows that insufficient vitamin intake can severely affect a baby's development. A vitamin A deficiency interferes with the development of the foetus and disrupts interaction between developing cells. As a result, there aren't enough of the cells needed to create the lymph nodes. These lymph nodes end up smaller than the ones in babies who get enough vitamins. That leads to an underdeveloped immune system, from which the baby will not recover later on in life. People who have a vitamin A deficiency in the foetus will also have a weakened immune system throughout their lives. Mebius discovered the effect in mice. As these rodents' immune system resembles the human immune system, the results are likely to be applicable to us too. What's important to realise is that the transmission of vitamins to the child is only dangerously low when the expectant mother suffers from malnutrition. That makes the research results especially pertinent for developing countries, where the administration of vitamin A, in addition to other positive effects, also strengthens unborn babies' immune systems.

dutch national research agenda

What questions will make it onto the Dutch Research Agenda?

WHAT THE NETHERLANDS WANTS TO KNOW

Anyone with a burning question for the scientific community had the opportunity to send it to the Dutch Research Agenda (NWA) last spring. In the end, almost 11,700 questions were submitted. What were these questions about, and what's going to happen with them now?

TEXT: ANOUK BROERSMA

It was the government that came up with the idea for the Dutch Research Agenda. The cabinet wanted the scientific community to focus more on major social issues. Of course, that means first figuring out what issues move people. To that end, a 'knowledge coalition' was set up to develop a science agenda. The coalition comprised the Netherlands Organisation for Scientific Research (NWO), the Association of Universities in the Netherlands (VSNU), the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Netherlands Association of Universities of Applied Science, as well as an employers' association, the Confederation of Netherlands Industry and Employers. In April, the coalition invited scientists, businesses, civil society organisations and the general public to send their questions to the scientific community online. The initiative was a huge success: NWA, who are housed with NWO in The Hague, had counted on 1,000 to 3,000 questions, but ultimately the tally stood at 11,687.

The process

During three conferences, researchers, civil society organisations and businesses tackled the questions and answers that are likely to be important in the coming years. The search for answers needs to resonate socially, and the answers need to be viable. A jury divided the questions into 140 umbrella categories.

Here are some examples: 'How does our brain process and retain information, and what role does plasticity play in this?' 'What are the consequences of new technologies and big data on the effectiveness of governance and the rule of law?' And 'how can we better understand and prevent the problem of overweight and obesity?'

And what to do with the many questions that researchers already know the answers to? Explain them, of course. For example, various scientists gave classes at the homes of people who submitted questions. And in late November many questions came to life during mini-classes and live experiments at the EUREKA! Festival in Amsterdam. ■

The contributors

- By far most questioners submitted their questions right before the deadline, on the last day or even in the last hours.
- Daily headlines sometimes gave questioners ideas. There were many questions about Lyme disease, for example, which had received media attention.
- The youngest questioner was four years old. He wanted to know why milk was white. 'My son,' his parent wrote, 'sees cows eating green grass, straw and hay. All of these foods have different colours. And still milk is white. How can this be?!'
- The oldest contributor claimed to be 117 years old, even though the oldest Dutch person is 110 years old. The subject of the question, which was a pretty technical question about internet and privacy, also leads us to believe that the contributor is a little bit younger than claimed.

Science fiction

Although many questions covered popular themes such as health and sustainability, some questioners seemed to be inspired by science fiction. Four striking examples:

- Is it possible to reach aliens by internet?
- If Mother Earth is alive, does that make humanity a cancer? We are a disease that destroys nature, according to the questioner. In fact, that's not an entirely original thought: agent Smith said just about the same thing in *The Matrix*.
- Did the pyramid builders at Giza have access to sources of energy that remain unknown to us and which could explain the precision with which they built structures and moved heavy objects?
- Is there some kind of wireless network connection between different people's brains? In other words, does telepathy exist?

What are Dutch people curious about?

Energy and sustainability were popular subjects among questioners. Can we generate energy from the dark of night, one asked? And is it possible to store energy locally that has been generated at home? Other frequently occurring key words among submissions were health, earth, economy and the universe. The brain is another subject that interests people. Those questions varied from brain development and brain complications to questions about the differences between people: where in the brain is the difference between believers and atheists located? How much do the brains of men and women differ?

And someone calling themself a 'travel addict' wondered which chemicals are released in the brain while we travel.

Many other questions concerned the internet and big data. How can we possibly draw useful conclusions from this surplus of data? Is it possible to build a truly safe web browser? What are the causes and consequences of internet addiction?

Some people linked people and computers together in their questions. For example, one person wanted to know how big our memory capacity is in terms of gigabytes, so that we can compare human memory to that of robots in the future. Perhaps the answer to that one is also interesting for the person who sent us the following question: are robots going to take over our work?

Regional science

Some contributors preferred to submit questions that were more close to home. The Zeeland Scientific Council, for example, submitted 65 questions, the lion's share of which were about its own province. An important issue was the shrinking and ageing population in the region. There were also all kinds of questions about the people from Zeeland and their typical characteristics. A small sample: 'Do people from Zeeland have special DNA?' 'Are people from Zeeland more sober than people in the rest of the country, and would you benefit from knowing the answer?' 'What forgotten vegetables exist in Zeeland?' 'Is it healthy to eat mussels from Zeeland?' And 'why isn't the huge volume of hydropower going through the Oosterschelde being used to generate energy?'

! MORE INFORMATION

wetenschapsagenda.nl: the Dutch Research Agenda's site, which also contains all the submitted questions.

‘Big data really has changed everything in statistics’

New opportunities

The amount of data that’s being saved on computers is growing exponentially. Datasets are so big these days that we need new statistical methods to analyse them. Professor of stochastics Aad van der Vaart is doing research on this. In 2015 he received the NWO Spinoza Prize worth 2.5 million euros.

TEXT: ANOUSCHKA BUSCH / PHOTOGRAPHY: ADRIE MOUTHAAN

AAD VAN DER VAART, professor of stochastics at Leiden University, received the NWO Spinoza Prize 2015.

Did this prize come as a surprise?
‘It did. You know that they may be considering you because of your CV. You’re aware of your standing in your field. But to actually receive a Spinoza Prize remains a huge surprise.’

You’re professor of stochastics. What does that entail?
‘Stochastics is just another word for probability theory and statistics. My focus is more statistics oriented: developing methods to analyse large and complex collections of data.’

What’s so much fun about statistics?
‘One of the things that I like about it is that it’s mathematics with applications. First and foremost you’re a mathematician, but you have to deal with medical science, economics and the social sciences, as well as mathematical problems in those fields. Statistics has permeated just about every other science. You learn a little about what’s important in other fields, and you notice that all that maths is good for something, that it’s not just an abstract theory but also something that works in practice.’

What are some of the interesting applications of your research?
‘Genome research is a good example. Suddenly, fifteen years ago, measurements of many genes were made available to doctors simultaneously. But they weren’t sure what to do with it all. There was a long tradition of applying statistics to medical data. But these data were totally different than what they were used to.’

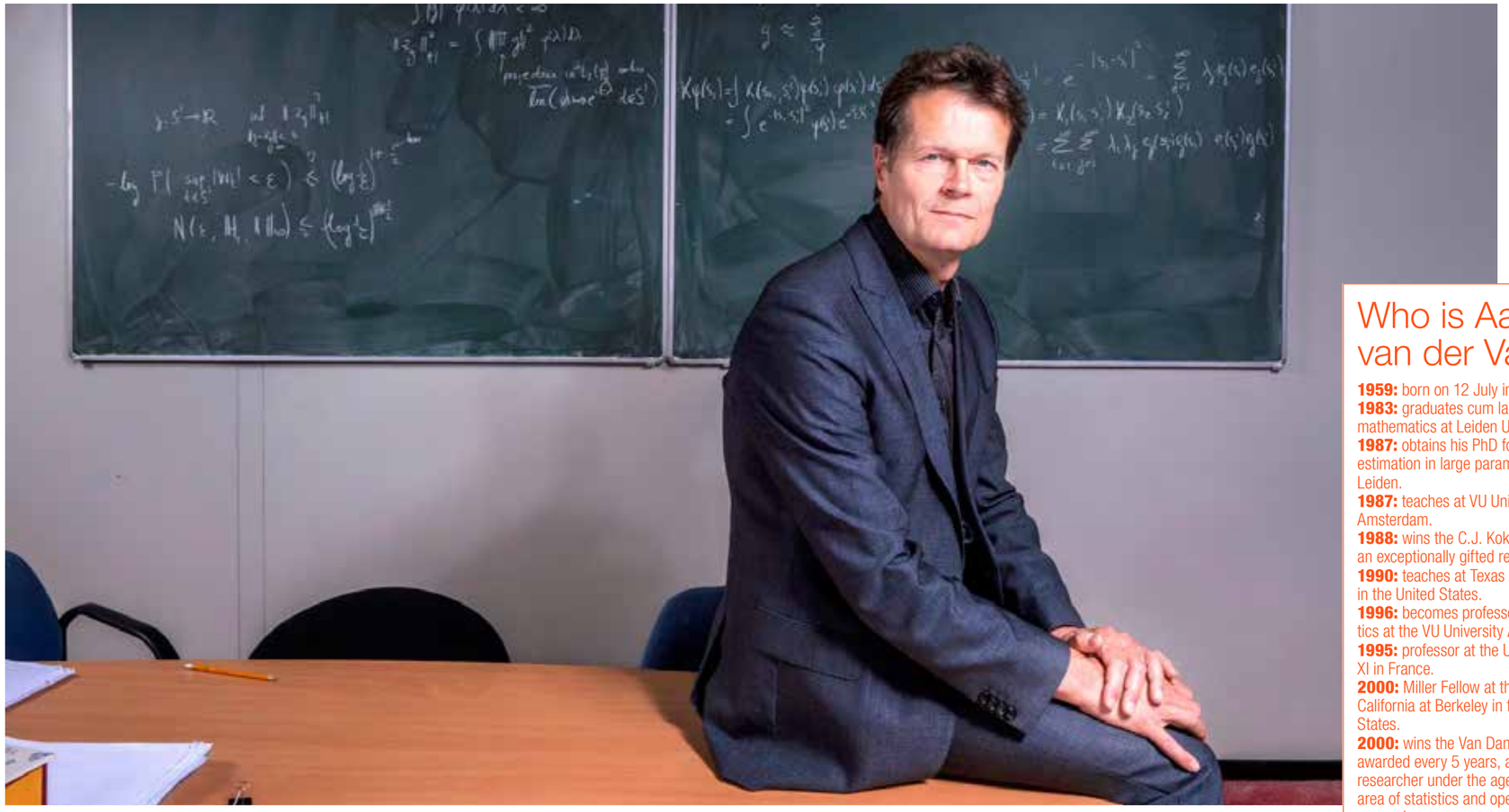
What was so different about these data?
‘Mainly how big they were. We’ve only been using the term “big data” for three or four years now, but genome research was in fact the first example of it. It concerned measurements of 30,000 genes simultaneously. And that’s fundamentally different than the limited amount of medical data that we had been dealing with before that, such as gender, blood pressure or cholesterol levels.
Big data really has turned statistics upside down. You used to be able to just scroll down a statistical dataset on your computer. Sometimes the files today are too big to even open in the standard way. There was a time when computers had become so powerful that we thought: now we can do anything. But meanwhile the amount of data has become so big that we have to take a step back. We have to keep our calculations simple, otherwise they won’t work. A calculation could potentially go on infinitely.’

So the problem is not just the amount?
‘No, it’s also the complexity. Imagine you want to find out which genes cause an illness. One way of researching this is to compare the genes of people who have and who don’t have the disease and see whether you can find any kind of pattern. In rare cases you strike gold immediately. You discover the culprit gene. But it’s usually more complicated than that. It could be that the disease is caused by more than one gene or interactions between certain genes. That makes it very complicated to find. I’m trying to develop new methods to extract these correlations.’

There’s been a lot of controversy lately about statistically flawed research, especially in the social sciences. Does that play a role here too?
‘Not directly. But the more you measure, the higher the chance that you’ll find correlations that initially seem statistically significant, but which end up, on closer inspection, not to be significant at all. If you compare the gene dataset of patients and healthy people, there’s always a chance that you’ll find a gene that is different, but also that your finding is complete coincidence. That’s what we call the p-value: the probability that your correlation was coincidence. We try to restrict that probability, to less than five per cent. In such cases, we call a correlation statistically significant. But if you make this kind of comparison often, then you have to keep adding these five per cents. If you compare twenty gene datasets, then you can be almost certain that you’ll find a difference that is purely coincidental. In the early days of gene research, I remember attending lectures where doctors proudly announced: “We have tested 10,000 genes and of those fifty were significant.” Well, that’s exactly what a margin of error predicts. So actually you haven’t discovered anything. Maybe there’s a gene there that’s causing this disease. But it’s also possible that there are fifty hits off the mark. Nowadays, researchers know that if they are examining 30,000 genes, then they have to apply a statistical correction. But lots of these kinds of studies are being conducted, and actually you would need to apply the same correction in these cases too. If many researchers are all reaching the p-value of five per cent, then you can be pretty sure that many of these results are spurious. In short, even studies that are well conducted statistically speaking and easily reach the p-value of five per cent, don’t always reach reliable conclusions.’

What other traps do statisticians have to look out for?
‘As a scientist you often want to say something about what the effect is when someone does something or eats something. Is it healthy to eat too much broccoli? To ▶

‘The real maths, the real thinking, is something you have to do yourself too’



▶ determine that you have to at least split your test subjects into two random groups. So you let one eat broccoli and the other not. If those eating broccoli live longer on average, then you can conclude that broccoli makes a difference. But that’s not how it works in real life. This kind of experiment is too complicated. Scientists look at the data that they already have: they compare the data of a group of people that they know eats broccoli and a group that doesn’t. But if that leads you to conclude that those who eat broccoli live longer on average, that doesn’t mean that you can immediately draw conclusions from that, because the groups were not randomly chosen. There can be all kinds of other differences between the people who do and do not eat broccoli. Perhaps those who eat broccoli also eat other vegetables more frequently, and perhaps they do more sports. That’s where statistics kicks in: test these alternative explanations. If a newspaper reports about research by saying that “the results have been corrected for age or income”, then that’s what you have to look out for.’

And if you make this kind or correction, are you sure then that your conclusions are right?

‘No, of course not. You have to examine what other variables could have potentially affected the outcome that you observed, and then you try to create a model to show how these two groups differ in terms of these other variables. The problem is that you often have many variables that could play a role. Correcting is in itself not so easy, by the way. A lot of research goes into that. And it will probably never reach perfection. I’m actually working on it myself with an epidemiologist from Harvard. Creating models is his expertise, whereas I look more at the mathematical side of these problems.’

What do you think of the idea that professors are managers that don’t have time for research?

‘That’s generally not true of mathematics. I prefer not to manage anyone. The people in my group are highly independent. They’re more partners than people I have to direct. As a professor you’re a little more above it all, so you ask questions: why did you do it like this, shouldn’t you try this approach? But you can’t “manage” mathematicians without doing some of the legwork yourself. If you’re not right in the thick of the content, then you’ll be side-tracked within three weeks. Because a smart colleague will have a massive head start on you. At that point you won’t even be able to join the discussion. But the legwork is the most fun part of it all. The calculations are the only thing you can outsource. The programming is extremely time consuming, and this is the kind of task you can delegate. And then eventually you all make a joint assessment: what was the outcome and how do we interpret it? But the real maths, the thinking, that’s something you have to do yourself too.’

So you’re thinking most of the day?

‘That’s right. It’s mainly about coming up with theorems and proving them. You want to make an assertion with absolute certainty and precision, like in all forms of mathematics.’ To prove his point, Van der Vaart points to an article he wrote, packed with formulas. ‘See, that’s what it eventually looks like: theorem and proofs.’

Can you immediately see what’s in the formulas? Do you read this like we read novels?

‘In this case, yes. But there’s nothing new here for me. If you’ve been in my field for a long time, then you’re surprised when freshmen ask: “Do we really have to learn all these complicated formulas?” It all seems matter-of-fact to me; these formulas aren’t complicated at all. But when I have to read new mathematics, I can only manage three pages a day – with a pen in my hand, taking notes and gradually attempting to understand more and more.’

What’s the greatest challenge today in statistics?

‘I think it must be uncertainty quantification, which always goes hand in hand with an estimate. So imagine a doctor who would like to be able to predict what kind of an effect a certain treatment will have. That always comes with a certain degree of uncertainty. In classic statistics, that problem is illustrated by the opinion poll. Say you ask 1,000 people how they’re going to vote, and 500 of them say: “for party A”. Then your best estimate is that fifty per cent of the population will vote for party A. But because you only asked 1,000 people, there will always be a margin of error. It’s not too difficult to determine what the margin is in a case like this. But an opinion poll is a simple model. The challenge lies in choosing 1,000 random people. Because there’s an imminent danger that your sample does not represent a country’s entire population. But the calculation itself is pretty straightforward.

It’s a completely different story when you have a group of patients in a hospital. All kinds of data can play a role when calculating the effect of a treatment. And you want to take all these data into account, especially in extremely complex cases when you have a huge amount of data at your disposal. At the moment, we know how to calculate the margin of error with simple datasets, but we don’t know how to with huge or complicated sets yet. You would have to measure all kinds of things and then tell someone: “This is the best therapy, and this is the probability that it will succeed.”

What are you going to do with the money?

‘I’ve just found out about the prize, so I haven’t really had a chance to give it much thought. But the first thing that comes to mind is to further support the teaching of statistics and try to make a more independent entity of the actual field. There are a fair number of statisticians in the Netherlands, but they are spread all over the place. There are a few in maths departments, a few in hospitals and some in the social sciences. And in economics of course: econometrics is for the most part statistics. And of course we’re all in touch with each other. We all belong to the association for statistics. And for five years now we’ve had a student doing a Master’s in statistics at the mathematics department, in collaboration with the Leiden University Medical Center and the social sciences department. But I would like to move forward and actually establish statistics as a field in its own right in the Netherlands. There isn’t enough exchange yet. It’s really useful when everyone learns from each other. Because what’s happening in the social sciences isn’t really any different from what’s happening in medical science. I’m not sure yet how I’m going to go about it. But presumably the money will be spent primarily on hiring clever people.’ ■

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Who is Aad van der Vaart?

1959: born on 12 July in Vlaardingen.
1983: graduates cum laude in mathematics at Leiden University.
1987: obtains his PhD for ‘Statistical estimation in large parameter spaces' at Leiden.
1987: teaches at VU University Amsterdam.
1988: wins the C.J. Kok Prize for being an exceptionally gifted researcher.
1990: teaches at Texas A&M University in the United States.
1996: becomes professor of stochastics at the VU University Amsterdam.
1995: professor at the Université Paris XI in France.
2000: Miller Fellow at the University of California at Berkeley in the United States.
2000: wins the Van Dantzig Prize, awarded every 5 years, as best Dutch researcher under the age of 40 in the area of statistics and operations research.
2003-2007: president of the Netherlands Society for Statistics and Operations Research.
2003-2011: visiting researcher at the Harvard School of Public Health in the United States.
2009: becomes member of the Royal Netherlands Academy of Arts and Sciences.
2012: becomes professor of stochastics at Leiden University.
2013: received Advanced Grant of 2.5 million euros from the EU for his pioneering research.

What did Van Gogh's paintings originally look like?

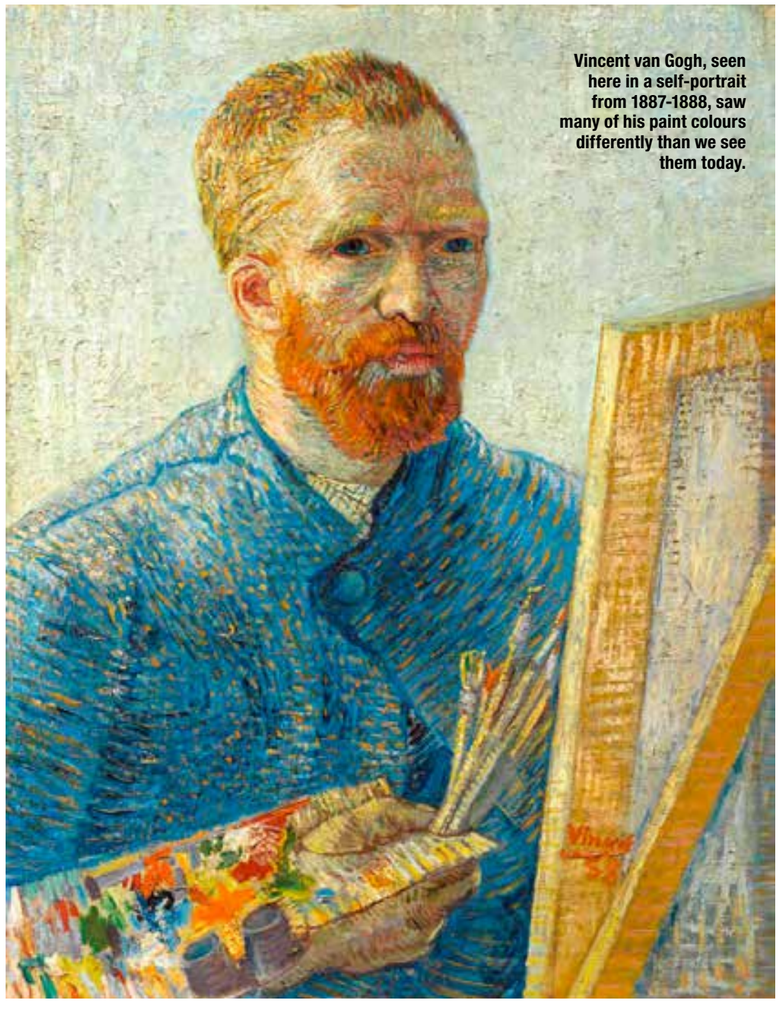
Vincent loses colour

From red to pink, from pink to white and from purple to blue: Vincent van Gogh's paintings change colour. In search of the most famous Dutch artist's colour palette.

TEXT: BERRY OVERVELDE

Discoloration is the result of reactions in the paint due to light exposure

Anyone looking at a painting by Vincent van Gogh (1853-1890) will often see a different canvas than he saw himself. Many of his paintings have become severely discoloured. A large team of researchers – from conservators and art historians to chemists and computer scientists – are examining this discoloration. Together they are trying to figure out why this has happened and what Van Gogh's paintings oringally looked like.



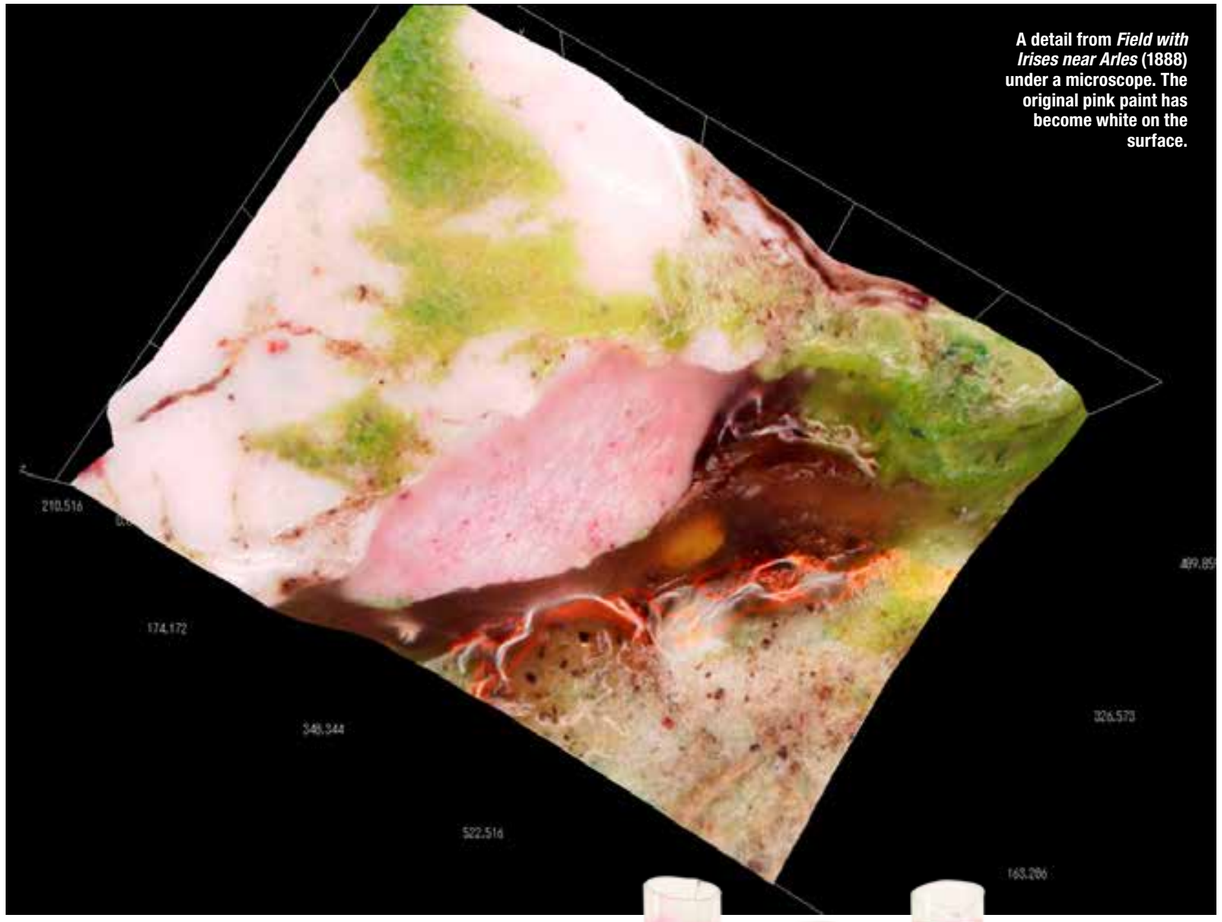
Vincent van Gogh, seen here in a self-portrait from 1887-1888, saw many of his paint colours differently than we see them today.

Evanescent red

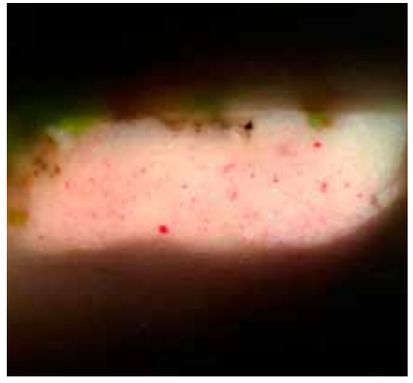
The most vulnerable paints are some reds and yellows, says Muriel Geldof. She is a chemist affiliated with the Cultural Heritage Agency of the Netherlands, where one of her tasks is to microscopically analyse Van Gogh's materials. 'Geranium lake, for example, is extremely sensitive.' Van Gogh often used this red paint, but in many cases it has already completely faded. Carmine (the pigment of which is derived from the female cochineal scale insect) also fades. Various 'chrome yellows', on the other hand, darken with time. 'There are different tints of chrome yellow, from lemon yellow to chrome orange,' says Geldof. 'The lighter tints are especially sensitive.' The loss of colour and discoloration are the result of reactions in the paint due to light exposure. They alter the chemical composition. For example, light causes some tints of chrome yellow chrome(VI) to react to chrome(III). That produces, among other things, chrome(III) oxide, which has a green colour.

Colder bedroom

How the colour deteriorates can be seen in the painting *The Bedroom* (1888), in which Van Gogh used a great deal of geranium lake. In a letter to his brother Theo, he writes that the colour in that painting 'will have to do the work' and should suggest tranquillity. 'The floor has red tiles,' he noted, while 'the walls are a pale violet,' and 'the doors are lilac.' The floor is no longer warm pink or almost red but a much colder purplish pink. And the walls and doors are blue. *Field with Irises near Arles* (1888), see pages 38 and 39, is also discoloured, the researchers recently discovered. The pink flowers in the field are white now, ▶



A detail from *Field with Irises near Arles* (1888) under a microscope. The original pink paint has become white on the surface.



▲ The top layer of paint from *Field with Irises near Arles* is 2/100ths of a millimetre thick. It no longer contains red pigment.

▲ Detail from *The Garden of Saint Paul's Hospital*. Once a colourful canvas, now faded.

▶ Van Gogh's paints are being reconstructed based on nineteenth-century recipes.

Van Gogh's paint is being reconstructed, based on recipes from his time, and aged

while the magnificent irises lean towards blue. To obtain the best possible idea of Van Gogh's original colour use, the researchers digitally reconstructed a few of his paintings – and more will follow.

Vincent's colours

How are these reconstructions done? The researchers collect information about how, and how fast, colours change. Ella Hendriks, senior conservator at the Van Gogh Museum, collects traces of discoloration on the canvases, for example. 'If you're lucky, you'll still see traces of the original colours under the frame, for example. Sometimes a fresh colour appears if you remove paint layers that were applied during past restorations.'

The difference in colour says something about the speed of the deterioration. The paintings are then subjected to scans (using what's called an X-ray fluorescence spectrometer) and other chemical examination. When Geldof studies paint samples from Van Gogh, sometimes she can still discern a bit of the original red under the faded top layer – especially when Van Gogh applied the paint thickly. How much red still remains in the deeper layers is an indicator of how fast the paint deteriorated.

Van Gogh's paint is also being reconstructed, based on recipes by paint manufacturers from his time. That paint is then artificially aged. All in all, says Hendriks, 'we have collected many different clues about the original colours.' These clues are entered into computer models, which eventually generate digital reconstructions of the original explosion of colours.

What to do?

However, Hendriks continues: 'We have also managed to show what *The Bedroom* will look like in the future if we don't take action now. That was very confronting. In the end, none of the red will remain. The floor, for example, will change from a pinkish to a more purplish colour in thirty years. All in all, it will be a very different painting than the warm bedroom the painter had in mind.' And this deterioration will also affect many other Van Gogh canvases, not to mention other pieces of art from that period, such as Pierre-Auguste Renoir's works – because many artists at the time used the same paint as Van Gogh.

Is there anything we can do against the discoloration? The research that can answer that question is still ongoing, but an initial measure has been taken. 'Our research has prompted us to further reduce the light levels in the museum,' says Hendriks. This will keep Van Gogh's paintings as colourful as possible for as long as possible. ■

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! MORE INFORMATION

tinyurl.com/vincentsrood: video about the research on colour change in Vincent van Gogh's paintings, in which conservator Ella Hendriks talks about her work, among other things.

The famous painting *The Bedroom*. On the left, how it must have once looked, according to the researchers, and on the right, what has become of it after 127 years.

How researchers captured photons

Taming light

PhD student Duygu Akbulut (left) and student Naser Hoseini discuss an optical set-up in the COPS laboratory at the University of Twente.

Light is intangible and untameable. Nonetheless, Dutch nano-scientists have succeeded in confining light particles, otherwise known as photons. Why would they want to do that?

TEXT: LIESBETH JONGKIND

'Yes, we like to do wild things with photons,' says Willem Vos, professor and nanophotonics expert at the University of Twente. He examined how you can get light to do things that would normally seem impossible. Why? Because you can create clever products with tamed light. Medical imaging equipment, for example, which emits a light pulse if it detects just one or a few molecules of a certain substance in your blood. For these kinds of applications you have to more or less capture light particles one at a time. And that is one of the complicated matters occupying Vos and his colleagues from the Complex Photonic Systems (COPS) group. For their work they need photonic crystals, minute silicon nano-mazes, which they make themselves. Recently they managed to successfully confine photons in a room in one of these mazes.

But there's more going on in the COPS lab. Nano-researchers from all over the world are working on new structures here to tame light, and young people are being trained as 'light scientists' or technicians who can develop new products. The lab is essentially a playground for light researchers. They frequently work together with the business sector as well. 'If industry knocks on our door with unsolved problems,' says Vos, 'then we welcome them with open arms. A few years ago, Philips Lighting asked us to investigate exactly how light scatters in popular white LED lights. We thought we'd solve that one in a few days, but it turned out there was much more to discover than we expected. My colleague Pepijn Pinkse is working on an unhackable security system for credit cards based on a photonic maze. So we're helping industry to move forward, and we're learning a great deal along the way.'

Colliding waves

To understand how the light prison works, we first have to go back to the basics: what exactly is light? There are several ways of looking at it. On the one hand, light is a way of transmitting energy in small, individual packages: photons. On the other hand, light is a wave phenomenon, because it moves in waves of a certain length. The length of the wave determines the colour of light that we see. Violet, for example, has a wavelength of about 390 nanometres (a nanometre is a millionth of a millimetre), while red has a wavelength of about 700 nanometres. Just as with other waves, 'interference' plays a crucial role with light. This phenomenon consists of waves that encounter each other and collide, and which can either strengthen, weaken or even completely cancel each other out. Free photons can only do one thing: race through space at the speed of light. Sometimes a photon collides with an object during its journey. A window, or a wall. Then three things can happen. Either the photon is absorbed and changes from light into heat; or it rebounds off the object and moves in a totally different direction (scattering); or it goes straight through the object and continues to travel more slowly in another direction. Which of these three things happens depends mainly on the photon's wavelength and the material it collides against.

Minute corridors

These properties of light are the starting point for nanophotonics researchers. But they're less interested in knowing how light reacts to objects that you can see with the naked eye. What they really want to understand is how photons propel themselves in the nano-world, where obstacles that light can collide with are much smaller. That's why Vos transmits light into a miniscule maze: a photonic crystal in which all corridors that the photon must pass through are just as narrow as the wavelength of light itself. The photons behave differently than usual in such a perilous environment. 'That's because of the small distance between the obstacles that the light encounter,' Vos explains. 'Photons can't just pass through there, so the light starts to do strange things as a result of the interference.' At ▶

The light prison can only close if you deliberately introduce a construction flaw

Twente they have succeeded in building a miniature room in one of these mazes, from which some photons are unable to escape: the light prison.

Porous silicon

This prison cell is at the centre of a miniscule block of silicon. The block is perforated by intersecting channels, 500 nanometres apart from each other. It resembles a pile of wood with tiny beams alternately stacked perpendicularly. Only these beams are made of air, they go straight through each other and are surrounded by silicon. 'Silicon is blue-grey,' Vos says, 'but because of its nanostructure a photonic crystal made of silicon reflects all kinds of bright colours on the outside, depending on the angle at which you look at it' (see 'Photonic splendour' box). Beautiful, but strange too. Because normally silicon absorbs visible light, but now it's reflecting it. Even stranger, it also reflects infrared light. Solid silicon is just as permeable to infrared light as glass. But that changes as soon as silicon has nano-holes. Infrared light, it turns out, is unable to penetrate it, and once a photon is in there, it has little chance of escaping. So why does light demonstrate such peculiar behaviour in a photonic crystal? The photons that collide on a photonic crystal keep encountering new obstacles. They travel from silicon to air to silicon to air, and so on. During each transition from silicon to air, they change direction. Because the light's wavelength and the distance between the two layers are in complete sync with each other, interference intensifies the reflected light but weakens the continuing light. Almost all of the photons (more than 99 per cent) in a bundle of light are reflected. That much light reflection is unusually high. The mirror in your bathroom, a reflecting object par excellence, won't even come close to that. On average, it reflects about ninety per cent of incoming light, while the other ten per cent is absorbed.

Forbidden entry

Of course, a wall that lets through one per cent of the photons is not solid enough to be part of the photon prison. Luckily, in every photonic crystal there is a wavelength that is reflected not 'only' 99 per cent of the time but the full one hundred. Each photon in a ray of light of that length is either absorbed or reflected. So that crystal is completely off limits for these photons. Which is handy, because if the photon can't enter, it won't be able to escape either if it does happen to get in. All you have to do is build a hollow in the centre of the photonic crystal where infrared light will not be absorbed. If you then put infrared photons into it, you have the perfect prison.

At Twente, they invented a clever way of creating this small space in the centre of a photonic crystal. The researchers built this prison cell by deliberately introducing a construction flaw in the crystal, for example by giving two intersecting holes a diameter that deviates from that of the other holes. A cell is created at that intersection, which is just as long, wide and high as the wavelength of the forbidden light. If forbidden photons end up there, they keep bouncing off their prison walls. They can't get out because the rest of the crystal is forbidden territory, where the light of that wavelength would be instantly absorbed.

Scrapping a projector

The big question is, if the forbidden light particle does not permeate the photonic crystal, how on earth will you ever get it into its cell? At Twente they use parts of a projector to achieve this. In 2007, COPS researchers Allard Mosk, Ivo Vellekoop and Ad Lagendijk devised a clever trick with mirrors that they call 'wave-front shaping'.

This discovery enables you to slow down or accelerate light along various channels, so that it intensifies exactly where you want it to as a result of interference. That allows you to steer photons in a certain direction. 'It works with a chip with millions of little mirrors, like the ones in projectors,' expolains Vos. 'We scrapped a regular projector to do this experiment.' After the mirrors are adjusted properly, they're able to transmit light through opaque materials, such as white paint, flower petals or egg shells. Or towards the photon prison. And as soon as you turn off the chip, the crystal becomes as impermeable as before, and the photons are utterly and completely trapped.

How many photons can you capture this way? 'You can easily stack photons in a pile without them disturbing each other,' Vos explains. 'You could probably fit ten trillion of them in the cavity.'

But won't it all explode? After all, so many photons in a tiny space have a lot of combined energy. Vos does not expect it to come to that. 'As soon as there's a leak, the captured light escapes,' he says reassuringly. 'And there's always a leak. The perforated grid is never entirely perfect. One hole is an atom larger or smaller than the other. Captured photons always break out of their prison at a certain point.'

Useful and harmless

So that's how the light prison works. But what use is a box in which you can imprison photons anyway? The honest answer to this question is: we don't exactly know yet. The people in Vos's lab are conducting fundamental research. The researchers are trying to increase their understanding of the world and not trying to develop a ready-made product. But this kind of research often leads to important innovations a few years down the road.

As far as the light prison is concerned, it might eventually be used in equipment that needs to transmit – or capture – one or a few photons at a time. Think, for example of highly efficient miniature lasers or tiny LED bulbs. Or extremely sensitive bio-pharmaceutical sensors, which emit a light pulse when they encounter one or a few molecules of a certain substance in your blood or drinking water. You could also build a photonic crystal with a cavity in an electronic chip. You would then have a switch that could turn the chip on and off with a single photon. 'If you create an entirely new research area, then the applications will always follow,' Vos says. 'And usually they are very different than what you may have initially imagined.' ■

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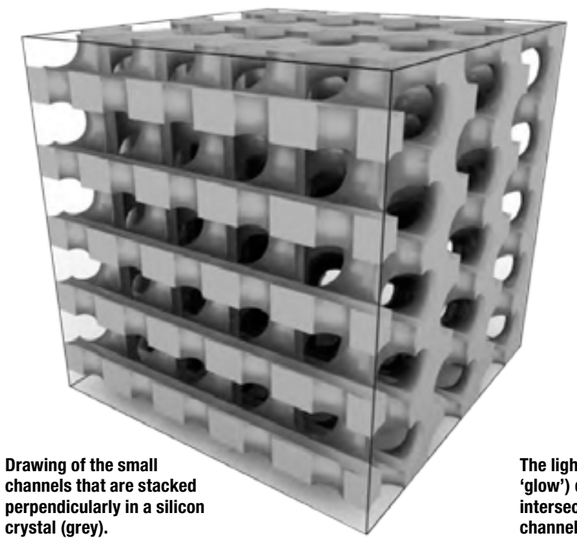
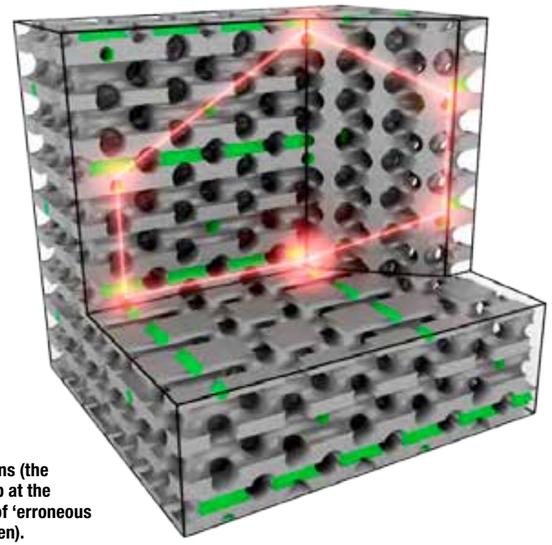
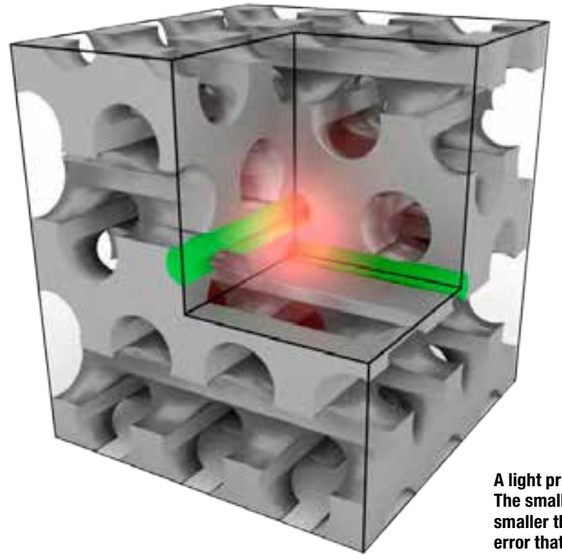


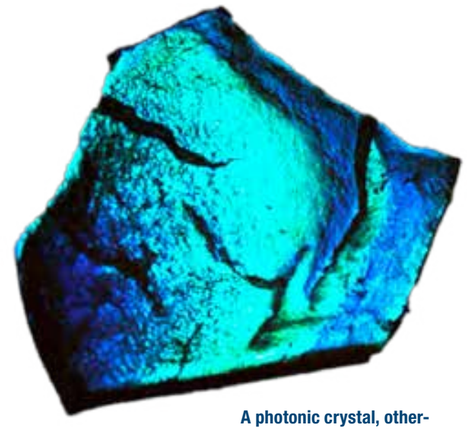
Drawing of the small channels that are stacked perpendicularly in a silicon crystal (grey).



The light prisons (the 'glow') develop at the intersections of 'erroneous channels' (green).



A light prison in close-up. The small green channels are smaller the others. That's the error that locks up the light.



A photonic crystal, otherwise known as silicon.

Photonic splendour

Light doesn't always travel at the same speed. Light travels the fastest in a vacuum: 299,792,458 metres per second. It moves more slowly in the air. Water, oil and glass slow down the speed of light even more. If a ray of light collides with an object, then part of the photons are reflected and scatter. The further light has to slow down, the more scattering there will be. Light that tries to permeate a photonic crystal will keep on colliding from a channel of air with a layer of silicon. Light travels as much as 3.5 times more slowly in silicon than in air. That's a massive change of speed. Most photons are therefore reflected and scattered. And that's why a photonic crystal looks so magnificent and sparkles more brilliantly than a gem.

Rogue light wave

Rogue waves in the ocean form completely randomly. Suddenly regular waves keep in precise step with one another, so that their crests get stacked on top of each other. Rogue waves are chock-full of energy, but they're not predictable. Nano-optics physicist Kobus Kuipers from the physics institute AMOLF creates rogue waves from light. He shoots flashes of light through a nano-tunnel and into a nano-room in a strongly reflective photonic crystal. The light leaves the cavity via a different tunnel. On the way to the exit, the photons collide wildly back and forth off the crystal's walls. But sometimes they momentarily move synchronously, at which point a rogue nano-wave suddenly forms in a random place in the sloshing light. What use is all this? We can use the energy in these kinds of light surges to speed up telecommunications, for example.

! MORE INFORMATION

iyl2015.nl: If you're interested in learning more about the festivities, here's where you can find out all about the activities taking place in the Netherlands during the international year of light.

How can we teach obesity patients to resist their favourite temptations?

The lure of the treat

Good food is hard to resist. ‘Eating professor’ Anita Jansen and her team are researching a therapy that teaches obesity patients to grow out of the habit of eating too much. Because healthy eating is easier said than done.

TEXT: MELANIE METZ

A billboard with golden chips, the aroma of freshly baked waffles, a giant plastic ice-cream cone. Walk through any shopping street and you’ll be confronted with countless gastronomic temptations. Chances are that you’ll give in and go for the waffle. It’s no wonder then that almost half of the adult population in the Netherlands is overweight, which is to say they have a Body Mass Index (BMI) of over 25. More than twelve per cent even have a BMI of over 30. That means they are seriously overweight, or obese. Of course we all know how to shed weight. It’s just a matter of eating healthy foods. It’s not that simple though. And that’s why clinical psychologists in Maastricht are researching a method that teaches you to resist treats: ‘cue exposure therapy’. So how does it work?

Just like Pavlov’s dog

‘No one eats only when they’re hungry,’ says Anita Jansen, professor of clinical psychology at the Maastricht University. ‘You eat for all kinds of reasons.’ Many eating moments are triggered by a cue, a signal that says it’s time to eat. A cue could be a specific time of the day, for example: breakfast, lunch or dinner. If you have lunch every day at noon, then you’ll get hungry around that time. ‘At a certain point, this cue – time in this case – is enough to activate the urge: I fancy eating something now,’ explains Jansen. It’s a conditioned reflex, famous from the experiment in which dogs started to salivate when Pavlov made a certain sound (see ‘Pavlov’s hungry dogs’ box). And that’s a completely normal response. Animals and people just happen to respond strongly to anything that reminds them of food. In terms of evolution, there was a time when that was useful. Food was scarce when we were still hunter-gatherers. It was important for us to quickly associate certain images or smells with food. Nowadays it’s usually less healthy to respond strongly to food stimuli. And this is especially true if you’re overweight.

Drooling on demand

The psychologists at Maastricht University want to know how to teach people to unlearn overeating. But they’re also conducting research into the mechanisms that taught them to overeat in the first place. How? ‘With boxes that have characters from children’s books on them,’ says researcher Karolien van den Akker. ‘We have one with *The Rainbow Fish* and one with *Elmer the Patchwork Elephant*. You see, we believe that you can make people associate anything with food.’ Even strange boxes. The researchers put chocolate in one of them, which the subjects were allowed to eat. So if the box with the fish contained chocolate, for example, then people made that association. Whenever the subjects saw the boxes, they could indicate, on a scale of 0 to 100, how hungry they were. And it turns out that once they had been given the fish box containing chocolate a few times, they rated it high on the hungry scale. ‘That happened really quickly,’ Van den Akker says. The subjects also produced more saliva, our body’s preparatory response to food, when they saw the chocolate-fish box.

The patient has to smell the food or take a bite of it, but is not allowed to eat it.

Pavlov's dogs

Anita Jansen's diet therapy is based on a learning theory. In other words, you teach your body how to respond to certain stimuli, such as a sound, an image or a smell. This method is also called Pavlov's conditioned reflex. Ivan Pavlov (1849-1936) was a Russian physiologist who studied saliva secretion in dogs. In his experiment, he would sound a metronome or buzzer, or he would give the animals an electric shock. Then he would give the dogs food. After a few sessions, the dogs began to secrete more saliva in anticipation of a tasty treat as soon as they hear the sound or felt the shock. Pavlov managed to refine the effect. When he let the metronome tick faster or more slowly before the treat was given, then the animals also started to drool when the tempo changed. Pavlov's research became world famous. In 1904 he received the Nobel Prize for Physiology or Medicine.

Sniffing your favourite snack

In some people, that strong reaction to food has to be switched off. But how? Researchers Van den Akker and Ghislaine Schyns, psychologists and PhD students at Maastricht University, have joined Jansen to study cue exposure therapy. First all the cues have to be in place for the subjects. 'We ask certain questions beforehand: in which contexts do you overeat? What exactly do you eat then, what brands or kinds of food? We then buy those treats,' says Schyns. How likely is that favourite treat going to be apple or cauliflower? 'Well, pretty unlikely,' says Schyns. 'People usually go for snacks. We have a lab full of chocolate bars and other goodies by Milka and Côte d'Or. But we've had to go to ice-cream parlours, and to Bufkes, a popular sandwich bar here, to buy a special local sandwich made with minced meat.' The exposure begins as soon as the favourite foods have been bought. The patient has to smell the food, really take it in, or even take a small bite. But they're not allowed to eat it. Isn't that awkward for them, sniffing food with a psychologist standing next to them? 'The therapist joins in,' Van den Akker explains. 'That makes the client feel more at ease. It's called modelling.'

Who's therapy for?

Although the research is still in full swing, a few obesity clinics and psychologists are already working with cue exposure therapy. However, health insurances are not always willing to reimburse the cost yet. It raises the question of whether you need therapy to shed a few kilos so you look better in your bikini or swim trunks. Food researcher Jansen agrees vehemently. 'I think it's a strange idea that people should go into therapy to lose few kilos,' she says. 'We're talking about a serious problem here and a psychological treatment. It really is meant for people with serious weight problems.'

Glued to the tube

The environment is also important for therapy to succeed. It's best to perfectly simulate the situation in which the patient normally overeats. That's often at home, in front of the TV. Do people find it difficult to stay away from treats while the rest of the family indulges? Then the rest of the family has to sit in and eat during the therapy session too. And again, clients cannot swallow a bite of the food that's put in front of them. Initially there's a therapist present, but eventually the clients have to do it on their own, sniffing their favourite snack. And then, instead of eating it, they have to throw it away. 'People find that difficult to do,' says Schyns. "Such a shame to waste something so yummy," they say. But that's the only way of disassociating all these signals – the TV, the feasting family members, the aromas – from eating an entire bag of crisps or box of chocolates. And that's how you learn to eventually resist treats.'

'Just' eat less

Although the therapy may seem a bit funny, with all that food sniffing, the reason for it is serious. 'Our conversations with obesity patients,' says Jansen, 'reveal that they are extremely happy to have the chance to talk about their experiences as a result of their eating behaviour. There are many preconceptions about overweight people, even among social workers. Obesity patients are stigmatised: "Oh, they just eat too much."' Schyns has witnessed distressing cases during her research, she says. 'It's sad to see how badly some people's lives are dominated by eating. One women had a penchant for chocolate. She had a whole ritual for eating it. During the research she had to cry and said "Food has me under its spell." Much the same way heroine and alcohol have drug addicts and alcoholics under their spell.'

A born gourmet?

Why is it actually that some people find it so difficult to stay away from yummy food? 'That's something else we're examining,' says Jansen. 'We're investigating whether obese people are quicker to make associations between stimuli and food.' Research has already shown that overweight people are more 'cue responsive': they respond more strongly to food-related signals. 'But we're trying to find out whether these people really do pick up on cues more quickly.'
Isn't a big appetite just something that's in your genes? 'Indeed, there are indications that some people are genetically vulnerable to becoming overweight,' says Jansen. 'And this vulnerability could very well be that strong response to food stimuli.' More impulsive people appear to have more difficulty unlearning their response to 'food stimuli'. 'But we need to do more research to discover which mechanisms are behind this,' says Jansen.

No wonder drug

Meanwhile, the first results of the research on cure exposure therapy are coming in. 'The very first woman to participate in this study has already lost five kilos,' Schyns says. 'That was after the first assessment. The woman told us: "And that's just by not snacking anymore!"' That's what it's all about,' Jansen says in support. 'If you stick to eating three times a day, you will lose weight. And unlearning that snacking behaviour is easier with this therapy than with lifestyle treatment.' Lifestyle treatment? Is that one of these diets that stresses healthy, balanced eating? 'No. It's what doctors and dieticians often give overweight people. Advice such as "you have to eat less." "You need a healthier diet." "Less fat, less sugar, more exercise." The idea behind it is: now that you know what to do, go and lose weight yourself. But if that were easy, obesity wouldn't be such a problem', says Jansen. 'Acquired behavioural patterns and automatic habits are often ignored in these kinds of treatment.' And there's something else that needs to be said about healthy, balanced diets. According to Jansen these diets ignore the question of whether people can actually manage these diets, where you have to constantly eat healthy food.
Is her therapy a wonder drug against obesity? 'Of course not. Initial results are promising, but we first need to know for sure whether this therapy really makes people lose weight. And that they can maintain their weight after that.' And if the method does end up having a lasting effect? 'Well, then that would save a lot of money on medical costs.' Indeed, obesity can cause severe health problems, such as cardiovascular disease and diabetes. A good treatment for obesity could put these problems to rest. But before we reach that point, Jansen and her team will have to invest some more time in food research. ■

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! MEER INFORMATIE

tinyurl.com/eetonderzoeken: more about the research being done by Anita Jansen and her colleagues.

A telescope designed to capture cosmic rays emerges from deep in the Mediterranean Sea

Fishing for neutrinos

A very special telescope is going to be installed at the bottom of the Mediterranean Sea. Its job is to detect particles that will enable scientists to look closely at black holes.

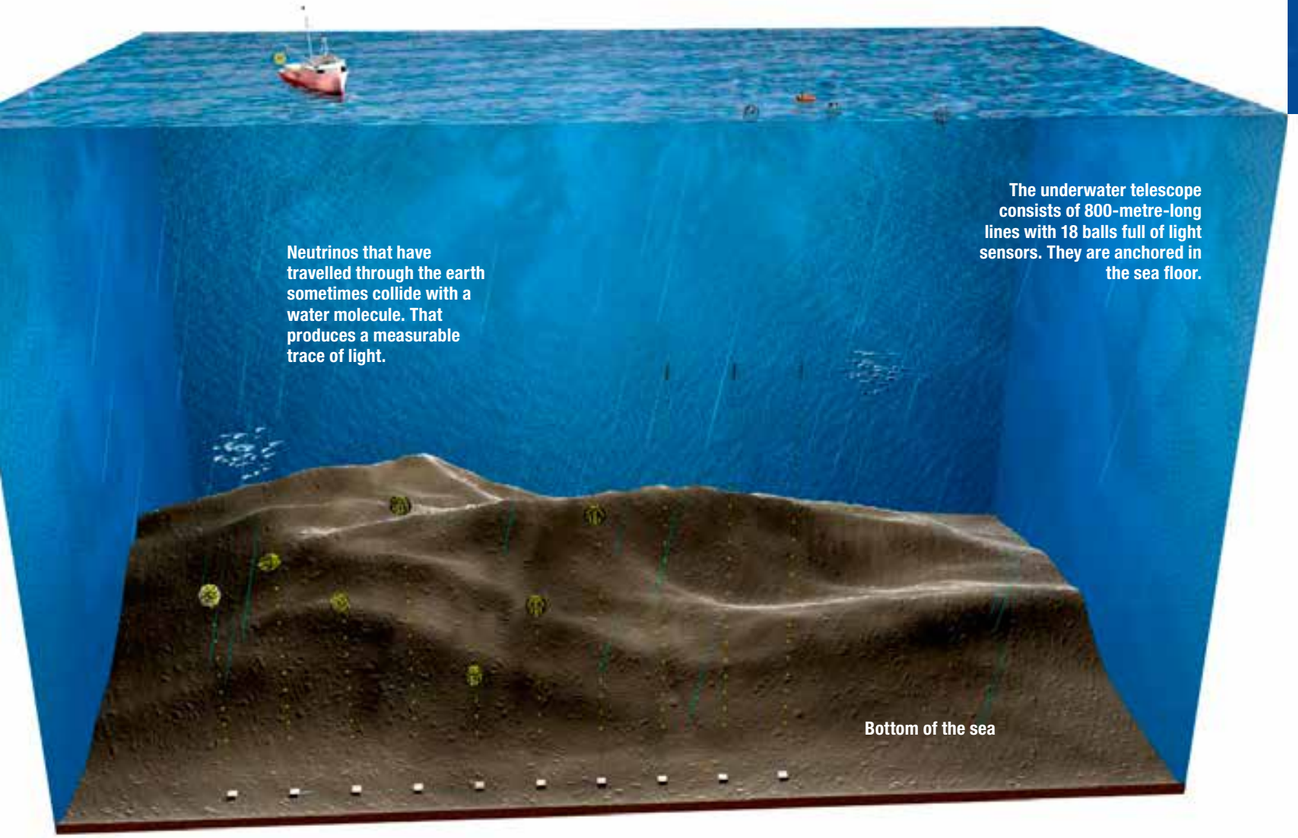
TEXT: JOP DE VRIEZE

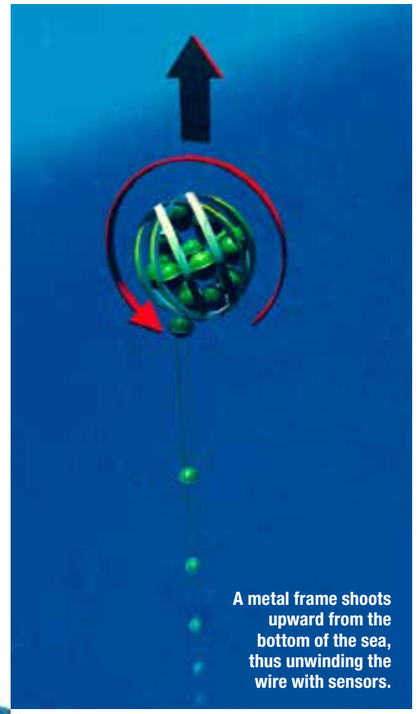
There's not much that can stop a neutrino – it can even fly through the earth

The workshop of the NWO institute Nikhef in Amsterdam looks just like a factory for disco lights. Lying on a long table are twelve synthetic and glass black balls. But researchers will fill these balls with sensors, not flashy lightbulbs. After assembly, technical engineer René de Boer tests some of them in a high-pressure chamber at 600 bar, about 600 times the air pressure at sea level. These balls are going to have to function three kilometres beneath the surface of the Mediterranean Sea. Together, about 6,000 of them will create a gigantic telescope about three cubic kilometres (km^3) in size, hence the name KM3NeT. NeT stands for NeutrinoTelescope, because that's what the researchers hope to observe with these balls deep under the sea: cosmic neutrinos.

Particle collides with water

Neutrinos are not rare in and of themselves. They are generated in abundance in thermonuclear reactions in the sun, and sometimes they are produced when cosmic radiation in our atmosphere collides with matter, and they are also created elsewhere in the galaxy. The latter are what we call cosmic neutrinos. While you read this, trillions of these particles originating from the sun are flying straight through you. That right there is the most important property of these 'ghost particles': because they have no electric charge, they let absolutely nothing get in their way or change their direction, not even planet earth. That's possible because matter is largely made of nothing, so one of these point particles can easily fly through it. On rare occasions, neutrinos will collide with a proton or a neutron, in a water molecule, for example. This creates another particle, a muon, which moves in the same direction. And unlike neutrinos, the muon is visible. It transmits a cone of blue light until it loses all its energy a few hundred metres further on. In a dark environment, that light is visible to the naked eye as a blue flash. But it's much smarter to detect muons with sensors. The combination of deep-sea water and darkness is the ideal place to spot muons.




A metal frame shoots upward from the bottom of the sea, thus unwinding the wire with sensors.

How to detect a cosmic neutrino

You can't see a neutrino, nor can you measure it directly. But when a neutrino collides with a water molecule, it creates another particle: a muon. Muons are also created when protons or other cosmic radiation collide with matter in the atmosphere (such as oxygen molecules). So how can you tell whether it was a muon or a neutrino? The researchers have devised a trick for that: contrary to all the other particles, neutrinos can travel through the earth. When they do, they fly out of the other side of the earth and upward through the bottom of the sea. If a muon is created as a result of a collision with a water molecule, then it will fly from the sea bottom towards the water surface. If a muon's blue light is captured from below by a KM3NeT sensor, then the researchers will know that this muon was a neutrino. But even then, it could be a neutrino that was created in the atmosphere on the other side of the planet. Because atmospheric neutrinos aren't produced in numbers simultaneously, the researchers want to detect at least a couple originating from a single point. If they happen to carry a great deal of energy, then they can only have come from space.

Help from sea experts

'I'm still hoping that one of the sensor balls will be rejected so we can use it for demonstrations,' says project leader Aart Heijboer, who is giving us a tour of the lab. 'You can't just take one with you because they cost about ten thousand each.' Heijboer is a physicist, but he encountered a number of things while building the telescope that were beyond the scope of his training. Where, for example, is the sea deep and calm enough to stretch out lines with hundreds of balls? And how do you know what's going to happen with the equipment at the bottom of the sea? That's why the international team of physicists received assistance from the Royal Netherlands Institute for Sea Research (NIOZ). As Hans van der Haren from NIOZ explains, they know all too well which materials can withstand salt, water and currents.
'That's all in a day's work for us.'

Unwinding the line

The KM3NeT team selected two spots in the Mediterranean Sea, south of France and south-east of Italy, at a depth of about 2.5 and 3 kilometres. They're going to install thousands of sensor balls in both locations, and together these will create one massive telescope. They're going to use 800-metre-long lines, consisting of wire four millimetres thick, like the type used by kite surfers. Eighteen balls will be fastened to each line. The ends will have a communication box that also serves as an anchor. They wrap the line around an aluminium sphere, three metres in circumference, and then lower it to the sea floor from a ship (see photo on pages 52-53). Then they detach the sphere from the communication box, and the sphere starts to surface, causing the line to unwind until it covers forty per cent of the total depth of the sea. As a test, the team anchored two dummy lines in the sea. That proved useful, because the data cable of the first one snapped. 'The clips fastening the cable to the line,' Heijboer says, 'weren't strong enough. So now we're using stronger clips.' Meanwhile, the whole operation to unwind the first real lines has been somewhat delayed. The forty-kilometre-long data cable near the French coast broke. 'It could be corrosion, but who knows, it could have also been a shark.'

Escaping a black hole

Scientists are putting so much of their energy into detecting neutrinos because they're hoping that these particles will teach them all kinds of things about the universe. When we look to the sky at night, we see light that has been transmitted from stars. But on the way, light is partly absorbed by objects in space, and that makes it difficult for us to determine exactly where the light originates from. Neutrinos can't be absorbed, however, so they provide information that regular light doesn't. Moreover, neutrinos are the only particles that can escape from nearby black holes and the centre of a star, such as the sun. We are familiar with neutrinos produced by the sun. But far more energy-rich neutrinos are coming our way from outer space. They are produced nearby energetic objects in space, such as black holes, sometimes billions of miles away from here. These objects function as particle accelerators, just like CERN's Large Hadron Collider, but ▶

High-level physics

In addition to the much-coveted cosmic particles, KM3NeT has to deliver something else too: basic knowledge about the properties of the different neutrinos that are produced in the atmosphere. Discoveries made in the CERN particle accelerator in Geneva, Switzerland have aroused physicists' curiosity. They are now certain that three types of neutrinos exist, but it's not clear yet how they differ from one another. There may even be one or two more types out there. The KM3NeT telescope off the French coast should be able to detect these neutrinos with great precision. That's why the researchers are deliberately placing the lines closer to each other. That may reduce the chance of capturing rare cosmic neutrinos somewhat, but it makes it more likely to capture atmospheric neutrinos. Those are much more common, but transmit a thousand times less light. So chances are slim that their light will reach a sensor ball. By learning more about the properties of neutrinos, the researchers hope to answer a question, or at least part of it, that has occupied them for decades: why does the universe contain matter, but not antimatter?

The last telescope saw 60,000 light flashes per second… from luminous creatures

then a million times stronger. These accelerated particles then collide with other particles, thus creating high-energy neutrinos. The researchers are hoping that their measurements will discover cosmic particle accelerators so they can better understand the processes in question.

ANTARES, the predecessor

As the telescope needs to stay underwater for a long time, it needs to be reliable. That's why the team first gained experience with the KM3NeT's predecessor, ANTARES. That was a prototype, with a 'mere' surface area of 200 by 200 metres and cables 300 metres long and fewer sensors per ball. It is located 2,500 metres below sea level, forty kilometres south of the French city of Toulon in the Mediterranean Sea. ANTARES has been useful for monitoring the findings of other research teams, because there are other neutrino telescopes, the most important one being the IceCube in Antarctica. This telescope, measuring one cubic kilometre, is under the ice. Ice allows more light in, which is an advantage, though the disadvantage is that the blue flashes of light bounce back and forth in the ice crystals, like a ball in a pinball machine. So IceCube can detect more muons, but all that bouncing back and forth makes it difficult to ascertain from which direction the neutrino came. When IceCube saw a number of neutrinos in the vicinity of the centre of the Milky Way, the ANTARES team questioned whether this was a genuine neutrino source. Otherwise they would have measured it too, thanks to good directivity. Indeed, ANTARES points to that part of the galaxy. 'It had to have come from somewhere else,' Heijboer says. 'From where, no one knows.'

Pull the plug

The plug is going to be pulled from ANTARES in late 2016. KM3NeT was supposed to be ready by then, but that's not going to happen. It's going to take at least two more years to install all the lines with detector balls. Indeed, Heijboer is a bit disappointed about ANTARES' meagre results: they weren't able to detect any cosmic neutrino sources. But Heijboer is not about to give up. Based on complex calculations, he is confident that they are close to recording neutrinos from the Milky Way. 'We're still collecting data, and we have a great deal to analyse. So while we might have already measured cosmic neutrinos, they still need to be statistically demonstrated. And otherwise, as soon as KM3NeT is up and running, we'll get to work again with fresh wind in our sails.'

The KM3NeT consists of 6,000 of these sensor balls.

What's lurking deep in the sea?

A network like this one at the bottom of the sea is unique. I can do more with this, thought Hans van Haren, physical oceanographer at NIOZ. He helped the physicists design their telescopes, and in exchange he was given the opportunity to take his own readings. He used all the equipment and even added some, such as thermometers, with which he could measure deep-sea waves. Indeed, he discovered why there is a resurgence of deep-sea plankton in the winter: a cold wind from the Alps cools the top layer of the Mediterranean Sea. Cold water weighs more than warm water, and while this water sinks, it brings food for the plankton with it.

Luminous creatures

One thing's for sure, in any case: ANTARES measured a massive number of light flashes. In fact, this telescope has measured as many as 60,000 of them per second, even though it was pitch black that deep in the sea. The flashes did not come from solar neutrinos, however, because the muons that develop from that don't produce enough light. So what was going on? Thousands of luminous creatures, such as fish and plankton, were swimming around the sensors. Luckily, the light that they emit is easily distinguishable from the light that muons emit, so it was filtered through software. Ultimately, five neutrinos remained per day, all of which were formed in the earth's atmosphere. Those weren't the flashes from far distances that the researchers were looking for. From 2017 onwards, the KM3NeT will detect more than ten times that amount. And every day the researchers will hope to strike gold: cosmic neutrinos. ■

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Political puppetry

Politics is often theatre, but theatre is also politics. This is evident from PhD research by historian Sadiah Boonstra from VU University Amsterdam on the Indonesian wayang form of theatre, which was given UNESCO heritage status in 2003. The first accounts of this puppet theatre originate from the colonial period. Dutch scholars reacted condescendingly and shunned the entertaining aspects, such as the silly and vulgar jokes. As a response to that, Indonesian nationalists emphasised the mystical and philosophical sides of wayang, which blended theatre, political cabaret and music. This is how wayang became part of an early national identity.
After independence in 1949, both president Sukarno and president Suharto reinforced Indonesian nationalism by institutionalising wayang. The theatre was strictly monitored and used for political campaigning. As cultural heritage, wayang was therefore constructed in correlation with a clear historical and political context, according to Boonstra. This interaction continues today. Thanks to the mass media, contemporary puppeteers are influential superstars. Puppeteer Enthus Susmono introduced George Bush (left) and Saddam Hussein to his theatre, to the displeasure of traditional devotees. His popularity didn't suffer, however. On the contrary: in 2014 Susmono was elected governor of the Tegal region.

Which building blocks of DNA cause coeliac disease?

Gene hunter

Why do some people get sick and others not? Professor of human genetics Cisca Wijmenga wants to map the genetic and environmental factors of diseases. In 2015 she received the NWO Spinoza Prize worth 2.5 million euros. ‘Perhaps one day we’ll find out how people can use their DNA profile to lead a healthier life.’

TEXT: ELLY POSTHUMUS / PHOTOGRAPHY: ADRIE MOUTHAAN

CISCA WIJMENGA, professor of human genetics at the University of Groningen, received the NWO Spinoza Prize 2015.

Did you expect the NWO Spinoza Prize?
‘I was sitting in a train from Maastricht to Groningen when they called me to tell me I was a laureate. It pretty much overwhelmed me. Gosh, me?! I was glad that I was sitting in the train with a colleague, who’s also a friend of mine, because I got quite emotional.’

Why do you deserve this prize?
‘I have been thinking about that, because there are many good researchers in the Netherlands. I actually serve on quite a few evaluation committees myself. Still, you can’t really compare the two. But I think I received it for my research on coeliac (pronounced: /'si:lıak/, ed.) disease, a common intestinal disorder. I’ve been studying it for twenty years now. And we keep moving forward, step by step.’

What’s coeliac disease?
‘It’s gluten intolerance. Gluten is the name of a group of proteins found in grains. When people with coeliac ingest these proteins it triggers an immune response, which makes them sick. They get gastrointestinal problems. About one per cent of people suffer from this affliction. They can’t eat bread and other products that contain grain. It might not be so difficult to avoid grain products, such as bread, cookies or pasta. But many products contain hidden glutens, for example processed foods. Some medicines even have a starch coating that contains gluten. The nature of a person’s reaction to a small amount of gluten varies enormously. Some people with coeliac disease can tolerate small amounts, while others get violently ill from a crumb of bread.’

What kind of research are you doing on this disease?
‘Coeliac is a complex hereditary disease, just like asthma, for example, or schizophrenia or cardiovascular diseases. There are perhaps a hundred hereditary factors involved in these diseases. But environmental factors also determine whether someone becomes ill and to what degree, such as lifestyle or, in the case of coeliac disease, diet. I began by unravelling the genetics of coeliac disease. Our entire DNA consists of approximately three billion building blocks, which create about 22,000 genes. There are about two million differences in these building blocks between two people. By comparing the entire DNA of groups of patients and non-patients, you can determine which of these DNA anomalies play a role in the condition. We were only able to conduct good hereditary research for the first time in 2006, because that’s when a technique came onto the market that enabled us to map people’s entire genetic material. Until 2005, that had to be done building block by building block. Now we can scan hundreds of thousands of building blocks simultaneously.’

And what have you discovered?
‘Ten years on, we have found differences in the DNA in forty places. Taken together, these forty places account for about half of this disease’s genetics. That doesn’t mean that there are only eighty places in total that differ, in fact it could be many more. You see, some of these differences in the DNA, or the genetic factors, have a greater effect than others. And you tend to find the factors that have a great effect first. The other fifty per cent of the genetics may be determined by 200 genetic factors. In order to find these less consequential differences, you have to study many more patients than the 12,000 whose DNA differences we have mapped so far.
We also discovered that genetic factors related to coeliac disease often cause other autoimmune diseases, whereby your body triggers an immune response against something from your own body or something that most people have no problem tolerating, such as gluten. The body of a person with diabetes type-1 aims its immune response at the islets of Langerhans. These are cells in your pancreas that produce insulin, the hormone that regulates your glucose metabolism. There appears to be a common genetic foundation behind these kinds of diseases.’

How can people benefit from knowing all the genetic factors of a disease?
‘Initially all you know is where the differences are. The next step is to understand what is in an area with DNA variation. What kind of a gene is it? And what regulates it? What’s going wrong, and in which cells? That’s what we’re concentrating on at the moment. It’s quite a puzzle to find out what the genes affect. We now know that the immune cells of people with coeliac disease work far too well. They actually react too quickly to things that ▶

‘I just jump into the deep end and hope I can swim’

they shouldn’t be reacting to at all. If we could find a way to weaken this response, then we could develop medicines to tackle that problem. But we haven’t reached that point yet, because what process would you then need to manipulate? We have to devote a great deal of research to that in the coming years.’

What’s the next step in your research?

‘In addition to genetic factors, the environment also plays a part. If you have all of the genetic factors for coeliac disease, then there’s a higher chance that you will get the disease. But that’s certainly not a given. There are also people who, genetically speaking, are at higher risk of getting coeliac disease or another complex disorder and still never develop the condition. We’re also trying to get a clearer idea of the environmental factors. I have really high expectations of the technology that will make that possible. If you walk around the whole day carrying your mobile phone with you, then there’s a great deal of information available about you. If we know when and where someone walks outside, the weather forecasting service can tell us what the quality of the air was at that point in time, for example. Technological developments are enabling us to collect more and more information. We can use these “big data” to identify patterns and establish links. We can then see how the air that you breathe, the food that you eat and how much exercise you get affect the development of diseases.

‘Of course, there are also other factors that are much more difficult to pinpoint, for which you need other data. Perhaps coeliac disease affects how often someone gets flu or what kind of infections you get in your lifetime. And that’s more difficult to monitor. We are now screening 167,000 people to calculate what the theoretical risk is for someone to develop coeliac disease based on these forty genetic factors. To also determine whether or not people actually have coeliac disease, we have to find out whether they have certain antibodies in their blood. We can use the money from the Spinoza Prize towards that work. Once we have a group that is genetically predisposed, but does not have the illness, then we can monitor them through time and discover which environmental factors play a role.’

And then?

‘Once you know who runs a high risk genetically of getting a disease and which environmental factors are important, then you can take targeted action. If you only know the environmental factors, then it all remains a bit abstract. Everyone knows the story of the smoker who lives to be ninety. So even though you know that smoking can kill you, it’s even stated on some cigarette packs, you still think it’s not about you, and that makes it harder to quit. But if you know that your DNA says that you personally have an eighty per cent chance of getting lung cancer, then that message will affect you differently. Research shows that people who are at higher risk of getting diabetes exercise more and pay more attention to their diet.’

What fascinates you so much about complex genetics?

‘When I began as a PhD student in 1989, the picture that we had of the world of genetics was still quite simple. We were aware of genetic diseases caused by one mutation in your DNA. But genetics didn’t immediately spring to mind with disorders like asthma, autism, diabetes type-2 or schizophrenia, but these have a hereditary component to them as well. They’re more prevalent in certain families, but they’re not passed down in a straightforward way. I thought it would be extremely exciting to unravel the genetics of these kinds of diseases because they have a major impact on public health. If we understand them and perhaps learn to predict who will or will not get sick, then that would have a significant impact.’

What are you planning to do with the prize?

‘One of the things I would like to find out is what protects someone who, genetically speaking, has a high risk of getting coeliac disease. Why isn’t this person getting sick? Of course, it’s useful to search for what does make someone sick. But what prevents someone from getting sick is just as interesting. Once you understand that, then that opens up an opportunity to look for new medicines or measures to treat the disease, or prevent it from happening at all. That’s an extremely difficult thing to discover – and maybe we’ll never succeed. But when I started unravelling the genetics of coeliac disease, everyone also said that it was so complicated and that I would never succeed. But now we’ve solved half of the problem. If you don’t try, you’ll never find the answer.’

What is your ultimate goal?

‘I really want to understand how I should interpret DNA. How does variation in DNA lead to disease, or not? Of course, you’ll never have certainty in your life. But we can take steps to increase the certainty of whether you will get sick or not, so that we can give people with a certain DNA more tangible rules to live by.’

Will we have reached a point in twenty years’ time where we really understand that?

‘Of course! Twenty years is a long time. Perhaps we won’t understand all complex diseases by then, but we will understand a number of them. If I look back twenty years, we knew and were able to do so little then. So if this continues, we can unravel many more mysteries in the coming twenty years. I have confidence in the future and in technology – not as a result of my own knowledge about what is or isn’t possible. As a researcher you should never be that naive. I just jump into the deep end and hope that I can swim.’ ■

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Who is Cisca Wijmenga?

1964: Cisca Wijmenga is born in Drachten, in the province of Friesland.
1988: Wijmenga graduates from the University of Groningen as a molecular biologist.
1993: four years later she obtains her PhD cum laude in the field of human genetics at Leiden University.
1994: she starts working for two years as a researcher at the National Human Genome Research Institute (NHGRI) of the US National Institutes of Health in Maryland.
1996: she starts working as university lecturer and later as senior lecturer at the University Medical Center Utrecht. She also sets up her own human genetics research group.
2001: she receives a Fulbright Scholarship to learn a new technique for a year at NHGRI.
2004: Utrecht University appoints her professor of human genetics.
2005: she receives an NWO Vici grant to do further research on the genetics underlying autoimmune diseases, specifically the intestinal disorder coeliac disease.
2007: she becomes head of the genetics department and professor of human genetics at the University Medical Center Groningen.
2012: The Royal Netherlands Academy of Arts and Sciences, a society of excellent Dutch scientists, appoints Wijmenga a member of the society. That same year, she receives an Advanced Grant from the European Research Council for her research on coeliac disease.
2013: Wijmenga is invited to become a member of the Academia Europaea, the European scientific academy.

Has the rise of women's football helped to advance emancipation?

Unlevel playing field

Last summer, the Dutch women's team participated in the football World Cup for the first time. Which is a good thing, if it weren't that women football players still don't have the status they deserve, according to researcher Martine Prange.

TEXT: MARK TRAA

Vivianne Miedema during the World Cup match against New Zealand. The Dutch 'Oranje' women won 1-0

After field hockey, football is the fastest-growing sport among Dutch girls

Footoball for women. ‘An amusing diversion that has nothing to do with sports. It will blow over, but it is enjoyable and fun, and in any case it pleases me to see that there are ladies who have taken a liking to the sport.’ Anyone aware that the Dutch daily *Het Vrije Volk* recorded these words, spoken by chairman of the Royal Dutch Football Association (KNVB) Hans Hopster, in 1955 will understand that women’s football has come a long way. The road to a successful performance by the Dutch women’s squad at the World Cup in Canada last summer was long. The struggle to gain acceptance for women’s football has been going on for over a century. In the meantime, football is the fastest-growing sport among girls in the Netherlands after field hockey.

But there’s still plenty of work to be done. Because as philosopher Martine Prange observes, there still aren’t equal opportunities for men and women footballers. She has been doing research on women’s football at Leiden University since 2013. She’s not only looking at its history, but above all at its social impact. Has football helped to advance the emancipation of women? And how does all the resistance to the sport affect the football players? Prange’s research reveals that despite the sport’s huge growth, the social resistance that footballers experience has scarcely diminished. They still feel they need to do more than men to prove themselves, and have to show the world that ‘as girls, they really can play football.’

◀ **The first football match between women took place on 23 March 1895 in England: North London against South London.**

Regular girls

Because the world of sport is so emphatically in the limelight, its problems and conflicts also receive considerable attention. They often reflect what is happening outside the world of sport. ‘It seems as if social discrepancies in particular are highlighted in sports,’ says Prange. ‘Doing research in this area gives you a good impression of the issues that matter to the public. It’s an extremely rewarding area of research.’ The people working on Prange’s research project, which is coming to a close in the autumn of 2016, have not only been interviewing current and former club players, but they’ve also been talking to ‘regular’ girls who play football in the street.

‘Sport brings people together,’ Prange says, ‘but it can also exclude people. What does that do to your personality? That’s an interesting question. On the one hand, women are entering a male domain, in which they are clearly “different”. But football also provides them with the opportunity to do what they like to do. So it’s also very liberating.’

Political choice

When Prange uses the word ‘exclusion’, she is referring specifically to the preconceptions and sexism that female players have had to deal with since the beginning. She went through it herself. ‘I was the only girl in my area that played football, and I never heard the end of it. That’s what sparked my activism.’

‘From day one,’ she says, ‘a woman’s choice to play football has basically been a political choice. As a young girl you just want to kick the ball around because you enjoy it. But from that point on you become a certain gender and that’s why you maybe shouldn’t have decided to play football.’ Women players were thus forced to wage battle off the pitch as well.

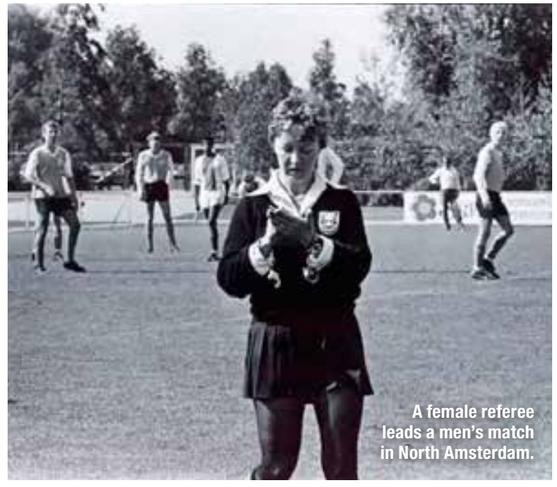
Martine Prange

Philosopher Martine Prange (1969) played football at the highest level in the Netherlands between 1985 and 1995. She also played in the Belgian and Turkish competitions and was selected for the Dutch national squad. Afterwards, she pursued an academic career. She was affiliated with the University of Groningen, the University of Amsterdam and Maastricht University, respectively, before she and Martijn Oosterbaan of Utrecht University were assigned an NWO Sport and Added Value grant to conduct this research in 2013.

Weak knees

In the past, detractors of women’s football were using arguments that Prange considers ‘absurd but actually shocking as well. They didn’t shy away from anything to get women off the pitch. They even had medical excuses: women’s knees are too weak to play football. Believe it or not, there are still people who think this way.’ In 1973, for example, a regional newspaper cited an orthopaedic surgeon who said the following about the difference in ball handling between men and women: ‘When a boy sees a ball on the street, he gives the ball a hefty kick. A girl grabs the ball and walks triumphantly home with it.’ The surgeon considered football too rough for women. A gynaecologist supported him, arguing that a new rule would be needed allowing women to protect their breasts with their hands during matches. ‘The development of the breasts is important for girls,’ he said. ‘Any attack on that can harm them mentally.’

A couple of girls at the OJC Rosmalen football club are so good that they play for the boy’s team.



A female referee leads a men’s match in North Amsterdam.

The Netherlands beat Germany 1-0 in their first international in 1956.

It’s always about looks

That was the seventies. You’d expect women footballers to have been taken more seriously since then. And yet in the nineties, Dutch goalkeeper Joop Hiele got away with saying – in the leading Dutch football magazine *Voetbal International* – that he only liked women’s football because ‘their breasts bounced up and down’. And a referee that led a women’s match in that era had the nerve to say that he ‘could barely see the difference between men and women among the players.’ ▶

Women aren't mocked any more, but they're still marginalised

Prange's research project is also analysing the way that female football players are portrayed in the media. There's a clear pattern in that respect: through the years, women's football has always been about their looks. And the tone has left a lot to be desired.

Critics usually came out studs first. In 1933, the magazine *Revue der Sporten* went around and asked famous Dutch people what they thought about women's football. 'Have you ever seen the face of a woman who is pushing her body to the limit? It's awful,' said Olympic fencer Willem van Blijenburgh. Or how about journalist Piet Kloppers: '[Women] smoke to make their teeth more yellow, they smear paint all over themselves to ruin their complexion and they play football to give themselves crooked legs.'

Indeed, these 'women with crooked legs' could never be 'regular' women in the eyes of public opinion.

'When you used to play football,' Prange says, 'you were lesbian, or about to become one. So the implicit message is that it's really bad to have a lesbian daughter. I find that really offensive. And it hasn't changed: our research shows that it's still all about masculine women. Lesbian girls in the national team are even trying to look as "unlesbian" as possible. As if "looking lesbian" even exists. And they're supposed to do that with nail polish and pigtails, as if it's something negative.'

Half a century of repression

So women's football has come a long way. It has existed in the Netherlands, in more or less organised form, since the late-nineteenth century (see 'Women's football timeline' box). That suggests it has been developing for more than a hundred years. But that's not true at all, according to Prange. 'From the 1920s onward, the Dutch football association was against it. The association and the clubs weren't allowed to organise anything. It wasn't until 1971 that women's football was acknowledged. That means there's been fifty years of repressive politics. The KNVB only reconsidered its position under pressure from the second wave of feminism. At that point there was no stopping it.'

Prange believes that the KNVB should actually apologise for the fact that women were kept off the Dutch football fields for half a century. 'All the progress that women have made here in the last one hundred years happened in spite of the KNVB. Morally speaking, it definitely has a great deal to atone for. But I don't think that the KNVB realises that an apology is in order. They just don't see it. The KNVB sincerely thinks that it's supporting women's football. But instead of being professionalised, it's being held back. Women comprise eleven per cent of the association's membership. So give them eleven per cent of the budget. But that's not even close to what they're getting.'

Women in FIFA

If it were really up to Prange and she were elected the new FIFA president, then she would surround herself with more female board members. She would create a separate section for women's football, preferably led by former players. 'Only those who have experience playing women's football know what needs to be changed,' Prange says. She would start by bringing together the European and World Cups for men and women. In her opinion, they should be played at the same time and in the same stadiums. Prange hastens to add that she doesn't expect women to actually gain more seats on the FIFA board anytime soon. We've got a long way to go, in her opinion.

'There is still constant discrimination at the micro-level. Women are given fewer facilities, even though they work just as hard as men. Women's teams still have to leave the training pitch sometimes because the men have to train there. Perhaps women players are no longer openly mocked, but they still feel that they are only being tolerated, that they're only allowed to participate because they can't be stopped anymore.'

Subtle vitriol

Prange makes an apologetic gesture. 'This isn't exactly a feel-good story, is it? We're often portrayed as a bunch of moaners. But I can't paint a picture that's better than it is.' The interviews conducted by Prange and her colleagues clearly illustrates that women players still feel neglected and inferior to men. She admits that her research exposes a paradox. 'On the one hand, women's football is good for creating social recognition of talent, as opposed to how you look. On the other hand, looks do play a role in generating public interest in the sport.'

The researcher also acknowledges that much progress has been made since the KNVB chairman brushed aside 'her' sport in 1955 as an amusing diversion. There isn't a football executive today who would dare utter such words, but the vitriol is still there, albeit it more subtly expressed.

'When men say that they think it's great fun and that their club really should do something about it now, they act like they've already done something for women's football. But why should I care if some guy likes it? The point is that clubs should stick their neck out and say that women can play on the main pitch on Sunday at two-thirty PM. Because they're the club's main attraction. Because they're going to become champions, and the men aren't. Our research shows that this kind of daily discrimination at a micro level is still common, and there's not a single female player that can't cite an example.' ■

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▲ **The 'seagulls' from VSV in Velsen play against each other in 1955.**

'The butch goalie keeps the ball out of the goal,' reads a newspaper from The Hague in 1934.

◀ **Desiree van Lunteren in action during the World Cup in Canada. Japan won 2-1, which meant the Netherlands were knocked out in the round of the last sixteen.**

Women's football timeline

1896: A British women's football squad invites women football players from Sparta for a match. It never gets played because the Dutch Football Association (NVB, the precursor to KNVB) threatens to throw Sparta out of the competition.
1924: the first official women's football club in the Netherlands, the Oostzaanse Vrouwenvoetbalvereniging (OVV), is founded. The club is not recognised by the NVB.
1930s and 1940s: years of crisis and the Second World War put women's football on the back-burner.
1950s: new teams are set up that play friendly and competitive matches outside the KNVB's jurisdiction.
1955: the General Women's Football Association is founded and starts a national competition for fourteen teams. The KNVB considers it a 'useless contribution to the development of football'.
1956: the Dutch national women's team beats Germany 1-0. Fourteen-year-old Lenie van der Jagt from Rotterdam scores for the Netherlands. It was never entered in the records as an 'official' match because the KNVB didn't organise it.
1962: the KNVB allows a female referee to lead a youth match for the first time.
1971: the KNVB recognises women's football. The number of squads increases from 130 to 385 in a year. An international against France, which is lost, is not yet recognised by the KNVB.
1981: regional competitions are launched. Bert van Lingen becomes the first coach of the Dutch national team for women.
1983-1984: the KNVB announces this season as the 'year of girl's football' and has 31,000 women members out a total of more than one million.
1984: first school football championships for girls.
1985: the KNVB has 36,000 female members.
2007-2008: the founding of a premier league for women in the Netherlands ushers in an era of professional women's football. Six professional clubs join the league.
2009: the Dutch women's team reaches the semi-finals of the European Championship in Finland.
2012: the BeNe League, a Belgian-Dutch women's competition is founded. It is discontinued after three seasons.
2013: meanwhile, the number of female KNVB members is 138,500.
2014: Netherlands under-21 women become European champions.
2015: the national team, nickname the 'Orange Lionesses', reach the last sixteen of the World Cup in Canada.
2017: the European Cup for women will be hosted by the Netherlands.

! MORE INFORMATION

tinyurl.com/vanvrouwenvoetbal: for more about Martine Prange and her team's research project.
tinyurl.com/VrouwVoetbal: broadcast by TV programme *Andere Tijden* about the history of women's football (May 2015).

Here comes quantum software!

Super software in the making

A great deal of time and money is being pumped into research on the quantum computer. But the software needed for these machines is receiving far less attention. Which is strange, because there's not much you can do with this kind of computer without software.

TEXT: ANOUSCHKA BUSCH

The quantum computer is the super computer of the future. Experts predict that within fifteen years these machines will have so much computing power that they'll solve hitherto unsolvable problems. They'll also be able to unlock many encrypted files, such as encoded messages from security services, but also credit card information that we send via the internet.

Of course, we need software for these quantum computers. And so far there isn't enough. But if Harry Buhrman, mathematician and computer scientist at the University of Amsterdam, has anything to say about it, then it won't be long.

No more zeros or ones

Can't we use our normal software on quantum computers? Unfortunately not. The main reason is that this computer uses a completely different computing system than regular computers. 'A classic computer stores information in the form of zeros and ones,' Burhman explains. 'Quantum computers work with qubits, bits that are in "superposition". In other words, they can be a zero and a one simultaneously. That has a big advantage: because of all the potential combinations of zeros and ones, they can be in many states at the same time, so you can use them to make many simultaneous computations (see 'Exponential growth' box). Unfortunately there's a big disadvantage too, because bits in superposition have the irritating characteristic that as soon as you look at them they become "regular" bits again. So if you want to view the outcome of your computations, then you won't see many simultaneous computations but only a single random one. And that's something quantum programmers have to find a clever solution for. Their software needs to ensure that of all these simultaneous computations, the only one left is the one you want the answer to.

A cracked code

Quantum software developers face the task of discovering applications that work with the crazy characteristics of this quantum computing. What kind of applications are we talking about? Decomposing numbers into prime factors is an example. That's the principle upon which the majority of our cryptography (encrypting files) is based. To do that you want to find the prime numbers for a number which, if you multiply them, result in that number. For example, for 15 that would be 3 and 5 because 3 x 5 = 15. One way of doing that is to try out every possibility one by one. Is the number divisible by 2? By 3? And so on, until a number has been found that is divisible by it. That would take a tremendous amount of time on a regular computer, especially with the gigantic numbers used in cryptography. Smarter methods have been developed, but they still take far too much time. But if things go as planned, you will be able to find the prime factors quickly on a quantum computer by using a clever quantum algorithm. It would take ages to hack the cryptographic key on a regular computer, but a quantum computer could probably do it in less than a minute.

Increasing the qubits

For now we don't have to worry that our credit card details will be made public. Quantum computers still have far too few qubits for that. The current record is ten stable qubits. To hack cryptography you need at least thousands of qubits. That's not to say that you can't do interesting things with a limited number of qubits. Quantum computers already seem to be good at things that classic computers struggle with. It also looks like the number of qubits will gradually increase in the coming five years. 'TU Delft,' says Buhrman, 'is working hard at developing stable qubits. Google has bought a large lab, and IBM is also trying to build stable qubits. The important question now is: what are all the things you could do with twenty or thirty qubits that you couldn't do on a regular computer?'

Simulating systems

One of the things that a quantum computer would be good at is simulating quantum systems, or systems that display quantum behaviour. In other words, they can be in multiple states simultaneously, just like a quantum computer. That means it's likely it can calculate the behaviour of the quantum systems more quickly than regular computers. 'Simulating quantum systems is what takes up most of the computing time of super computers at the moment,' says Buhrman. Those are computers with huge computing capacity that can only be found in a few places in the world. Only the future can tell whether quantum computers will really be good at these kinds of computations too. 'Right now we don't really understand what we can and cannot do with a quantum computer,' says Buhrman. All the more reason to do research on quantum applications. 'A lot of money is being pumped into building quantum computers, so we have to focus on what you can do with them too.' ■

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MORE INFORMATION

universiteitvannederland.nl/college/hoe-kan-een-kwantumcomputer-overal-inbreken: Harry Buhrman explains during a class what the big advantages and dangers are of quantum computers.

Exponential growth

Quantum computers use qubits. For each additional qubit, the number of states that the computer can handle doubles. In other words, one quantum computer with N qubits can handle 2 to the power of N states simultaneously. This 'exponential growth' can increase rapidly. 2 to the power of 30 is already the number of bits in a laptop, and 2 to the power of 300 is already much more than the total number of molecules in the universe. The number of computations grows exponentially in tandem with the number of states. With every ten bits that are added, the potential computing power of a quantum computer increases by a factor of about a thousand.

Why are hunter-gatherers so good at describing smells?

Capturing **smells** in words

Asifa Majid conducted research with the Jahai in Malaysia. They're much better at naming smells that westerners.

Westerners generally have one or two words to describe certain smells. Hunter-gatherers sometimes have more than ten. Why the difference?

TEXT: FRANK BEIJEN

Bananas are yellow. Oranges are, well, orange, and kiwis are brown on the outside and green on the inside. It's easy to describe what a piece of fruit looks like. The Dutch language, for example, has eleven basic words for colours and a series of sub-colours, like orange-red, chestnut brown and khaki. But try explaining what a piece of fruit smells like. That's much more difficult. Indeed, like most western languages, there's something strange going on with most Dutch smell descriptors. Either they're derived from taste (sweet, sour), or they refer to a specific condition (mouldy, smoky), or they express a judgement (tasty, vile, penetrating). The only words in the Dutch language that really describe smell are the equivalent of 'musty' and 'mawkish' in English. Some languages have many words to describe smell. Jahai, the language of a group of hunter-gatherers on the Malaysian mainland, is an example. It has at least twelve smell descriptors. Such as *tjngus*, which describes the aroma of petrol and smoke, but also bat faeces, the wood of the wild mango plant and ginger root. 'One characteristic of these smell descriptors is that they say nothing about the object emitting the smell,' says Asifa Majid, professor of language, communication and cultural cognition at Radboud University Nijmegen. 'They contain no judgement, that something smells good or bad, for example. Speakers of Jahai don't have to think before they use a smell descriptor. In terms of user friendliness, they're more comparable to red and blue than scarlet red or marine blue.'

Smell is misunderstood

Linguists have been researching descriptions of colours for more than fifty years now. But for a long time, Western scientists have turned their nose up at the language used to describe smell. 'The Greek philosophers Plato and Aristotle thought that smell could not be described through language. That's a persistent notion,' Majid says. 'Modern researchers, such as the Harvard psychologists Howard Gardner and Steven Pinker, say that there is a marked difference in the way we perceive smell and visual information. They believe that we cannot capture smell in words – in fact, we can barely distinguish one from the other.'

Indeed, research has shown that people are bad at describing what they smell. Test subjects asked to identify common foodstuffs such as coffee, peanut butter and chocolate could only do so twenty to fifty per cent of the time. 'If you scored that poorly on a test for image or sound, I would send you to a hospital for a check-up,' says Majid. 'But if you look closely at studies on our ability to smell, something strikes you: they're almost all from western countries. Just like almost all psychological and linguistic research.' And in the west people use this sense differently than elsewhere in the world.

It's not so easy yet for a westerner to describe the smell of an orange.

The Jahai describe colours just as effectively as smells

▶ 'Modern society is set up in such a way that we no longer need to rely on our sense of smell. We look at the date on food packaging instead of using our nose. So that's quite a problem, if the amount of food we waste is anything to go by.'

An unlikely find

Smell plays a much more important role with the Jahai in Malaysia. For a long time it was not clear how it was embedded in their language. Swedish linguist Niclas Burenhult studied the language for eleven years, but even he only knew a few smell descriptors. 'That changed during an experiment with standardised sets of colours, sounds, tastes and smells,' says Majid. 'We carried it out with speakers of different languages. It was only then that Burenhult noticed what an extensive vocabulary there was for smell in Jahai. When I received his research findings, I didn't believe them at first. As far as we knew, a language with twelve words for smell was impossible.'

Majid went with Burenhult to Malaysia to conduct further research. Once in the jungle where the Jahai live, they understood why smell is important there. They soon realised that there are many more smells there than in our well-manicured living environments in the wealthy west. The tropical forest is crammed with smells, from flowers to elephant dung. They spent time with the Jahai on their jungle forays, during their rituals and all other daily activities. They had the Jahai describe the smell of objects, which the hunter-gatherers often did by way of the properties of the smells. They refer to the smell of some prey, such as civets and rodents, as *pl'eeng.* And *pl'eeng* smells are regarded as risky, because they could potentially attract tigers. The Jahai never wash meats with a different smell together in the river. They are afraid it will anger their deity.

Awful

The difference in the way westerners and hunters deal with smell is not only reflected in their vocabularies but also in how they describe aromas. Indeed, Majid subjected ten Americans and then Jahai to the same test. They were presented with twelve aromatic substances packaged in capsules that you can scratch open. When asked what they smelled, the Americans gave very different answers and needed five times as many words to describe the smells as the Jahai. The Jahai used their trusted smell descriptors and usually agreed about which descriptor was most appropriate. Which is striking, because most of the smells in the test (such as cinnamon, chocolate and paint thinner) should have been very familiar to the Americans.

The Jahai describe colours just as effectively as smells. They need just about as few words for that and their answers barely differ from one another. The Americans performed just as well as the Jahai with colours.

The Dutch are just as awful at describing smell as the Americans. When Majid repeated the experiment, but then with thirty Dutch people and thirty Jahai, the Jahai thought two seconds on average before answering. The Dutch needed thirteen seconds of thinking time on average.

Research with the Maniq, a people who have about fifteen smell descriptors.

Eleven Pirahã are pictured here in a canoe, although they would never say so themselves. This people speaks a numberless language.

Maniq are record holders

Western speakers from the Netherlands and the US have in common that they are bad at describing smell. As it turns out, the Jahai are not the only hunter-gatherers that are good at it. The record holders for now are the Maniq, a people from the south of Thailand. They use about fifteen smell descriptors. An important question in Majid's research is what determines whether a language has many or few words to express a smell. 'Culture is probably the determining factor: whether you live in an industrialised environment or as a hunter-gatherer. Perhaps people in other areas simply have a better sense of smell. That could be the case because they use the sense more, but perhaps they're genetically predisposed. Another explanation could be the environment. Pollution could harm our ability to smell. And smells are more penetrating in jungles, for example, where temperatures are high. I suspect that it's a combination of these kinds of factors.' For now, these researchers have plenty of material to examine. For example, it's not clear yet whether all hunter-gatherers are good at talking about the things they smell. But we are leaning more and more about it. There are hunter-gatherers in Mexico who have relatively many smell descriptors. And there are also indications that this is true of some peoples in Africa. 'Unfortunately not much research has been done yet,' says Majid. 'And those who do it have to be thorough about it. You need a great deal of knowledge about vocabulary, grammar and culture before you can know exactly how impressions such as smells can be expressed in language.' Moreover, we need to find out whether people such as the Jahai and Maniq are better at identifying smell than we are. Because it's one thing to capture smell in words, but that doesn't automatically mean that you have a more advanced sense of smell. But beware: you can't postpone this kind of research forever. It often deals with languages spoken by oppressed peoples. Jahai is still spoken by about a thousand people, Maniq only by 300. ■

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The smell of a civet is called *pl'eeng* in Jahai and is regarded as dangerous.

The Jahai only need two seconds to describe a smell.

Language controls our views

Is your view of the world controlled by the language you speak? There is increasing evidence that this is the case.

ENGLISH SPEAKERS KNOW WHO DUNNIT

Darn, who popped the balloon? American cognitive scientists Caitlin Fausey and Lera Boroditsky showed videos in which something goes wrong to English and Spanish speakers. In English, you are likely to say: 'He popped the balloon.' A Spaniard would probably say: 'The balloon popped.' Apparently these linguistic patterns have an influence on the information that we store. English speakers are more likely to remember who the perpetrator was.

ABORIGINAL AUSTRALIAN KNOWS WIND DIRECTION

Different languages spoken by aboriginal Australians, including Kuuk Thaayorre, use the wind direction instead of left and right. Speakers of these languages are always aware of east and west. Lera Boroditsky had the Kuuk Thaayorre order photos depicting an event (such as a banana being progressively eaten). Speakers of Dutch order these pictures from left to right. Aboriginal Australians ordered them, no matter in which direction they were seated at the time, from east to west.

THE PIRAHÃ DON'T COUNT

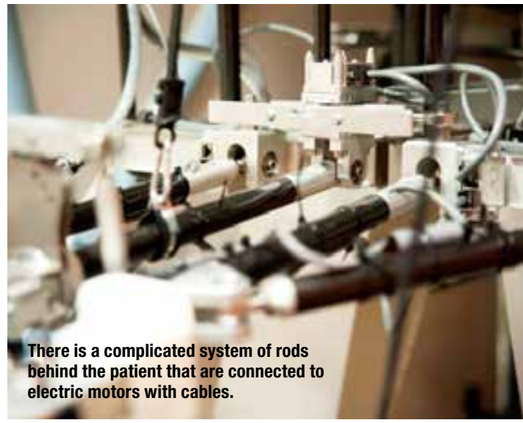
The Pirahã have words for 'a small number', 'a large number' and 'a great many'. But this people from the north-west of Brazil don't have numbers. The Pirahã don't count, they estimate. Linguist Peter Gordon from Columbia University (US) discovered that they have difficulty remembering how many objects are lying in front of them.

Walking robot LOPES helps patients suffering from paralysis to move again

Learning to walk with LOPES...

Learning to walk again is hard work for people suffering from paralysis, both for the patient and the physiotherapist. Walking robot LOPES II can help. This training robot may even be able to teach patients to improve their gait.

TEXT: ANOUSCHKA BUSCH



There is a complicated system of rods behind the patient that are connected to electric motors with cables.

The robot was designed so that a patient could be buckled in in five minutes.

It looks a lot different than the robots from science fiction films. But the 'thud-whoosh' of the walking robot's motors in the Roessingh rehabilitation centre in Enschede sounds like there is one walking around in the room. Today physiotherapist Martijn Postma is serving as patient in order to demonstrate the rehabilitation robot LOPES II. Physiotherapist and researcher Bertine Fleerkotte is standing behind the controls. Postma is hanging in a harness much like a parachutist, with his feet on a treadmill. His legs are fastened in what resemble braces. All kinds of rods connect his feet, legs and pelvis to a robot behind him. When he walks on the treadmill, it seems as if there are shadow legs behind him in perfect sync with his movements. The opposite is true: the robot is controlling his steps. So what's the goal of this bit of technical wizardry? To teach people who are partially paralysed by spinal injury or a stroke how to walk again.

Robots make it easier on everybody

The idea behind the walking robot is the same idea that's behind regular rehabilitative physiotherapy: by moving someone's legs, you stimulate the brain to create new nerve pathways to replace the ones destroyed by the spinal injury or stroke. 'When you get the paralysed patient's leg to make the right movements, a stream of information flows to the brain, as a result of which it can relearn the movement,' explains study director Jaap Buurke. Normally, that movement is done by hand. Now the robot does it. 'Walking robots started as a way of training people with a spinal injury,' he says. Only it's not easy to try to get someone who can't stand to walk. 'There was a time,' Buurke says, 'when you needed two or three people to do that, and it wasn't always easy to get someone upright.' Later the treadmill was introduced. Patients hung there, just as they do with the walking robot, in a kind of parachute suit above the treadmill. All the physiotherapist had to do was move the patient's leg with his hand. And still it was hard work. 'With people who can still walk by themselves to some extent, it's best to just support them when needed,' explains Buurke. 'But when someone is totally unable to do anything, then it's a huge effort for both the therapist and the patient to get the patient to walk.'

Correcting consistently

Another advantage of the walking robot compared to traditional physiotherapy is that it's easier to correct a patient's gait, says Buurke. 'A physiotherapist keeps the patient in balance and provides the patient with the chance to experiment a bit, but we are barely able to focus on the quality of the walking at all. A walking robot enables you to correct gait much more consistently.' Walking robot LOPES II carries out the correction based on the gait patterns of healthy people. To determine that, researchers at the University of Twente had test subjects walk on a treadmill at different speeds. Because when you walk slowly, you move differently than when you walk really quickly. These examples were used to create 'standard gait patterns'. The robot uses them to control the patient's walking.

But the physiotherapist can do that as well. 'As a physiotherapist, you could ask yourself: what do I want to improve about this gait pattern? This software enables me to do that in very specific ways,' ▶

‘The feeling of being able to walk normally again is extremely motivating’

says Buurke. ‘For example, I can increase or decrease the degrees of freedom around the pelvis, or the foot position, the leg swinging forward or the stance phase. That’s handy, for example, for patients who are paralysed on one side. They tend to overextend their knee because they don’t have any muscular strength around the knee. To influence that pattern, LOPES II ensures that the knee does not overextend, but remains slightly bent. That’s important, because if you learn to walk with an overextended knee, it will eventually break down. And walking like that looks strange. ‘Patients often think that the quality of gait is important,’ says Buurke. ‘They attach great value to how they look. But it’s difficult to improve the quality of gait. ‘We can certainly teach people to walk functionally again. In other words, get safely from A to B, but with a different movement pattern. But it’s impossible to teach anyone how to really walk normally again.’

The big question is whether LOPES II can help with that. That is what Fleerkotte is studying, in Enschede and at the Sint Maartenskliniek in Nijmegen, who also have a LOPES robot. Both clinics recruit patients to participate in experiments. One group receives normal therapy, while the other group receives part of its therapy in the LOPES.

Into the suit quickly, please

Information from physiotherapists from Roessingh and the Sint Maartenskliniek has been processed into LOPES II: what demands does the robot have to meet for them to actually start using it? Researchers from the University of Twente worked on the technical development of the robot with technology companies Demcon and Moog. They tried to incorporate the advice they received from both clinics into their design.

One of the physiotherapists’ demands was that it had to be easy to work with the robot. It needed to be easy to operate and you had to be able to work fast with it. You need to get patients into it quickly, train them, and get them out again, says Buurke. ‘That’s the reality of health care: you’re only given half an hour to train. So our goal was to be able to get someone into the apparatus in five minutes.’

As if you’re really walking

There was another important point: will the robot give the patient enough freedom of movement when walking? Can you walk in the apparatus like you normally would? The physiotherapists wanted it to be possible to wave your arms while walking, for example. In that respect, this robot is unique, says Buurke. ‘There are comparable robots in other countries, such as the Lokomat in Switzerland, but this is the only apparatus that allows so much movement. Rotating joints are not possible on standard walking robots. But that lateral movement is one of the key factors that determines how you walk.’ For example, normally you move your hips a little when you walk. If you can’t, then you have to compensate, either by changing the distance between your feet or by swinging your torso. Fleerkotte demonstrates what that looks like. She adjusts the LOPES in such a way that it mimics the behaviour of a classic walking robot. ‘Now Martijn’s hips are completely fixed,’ Fleerkotte says. ‘You’ll see him start to really compensate by making a lateral movement.’ Indeed, Postma wavers a bit on the treadmill. ‘Essentially this teaches someone the wrong walking technique,’ Buurke says. ‘The input to the brain is not normal, so you can’t expect someone to learn how to walk normally.’

Support when necessary

Another advantage of the LOPES II compared to the classic walking robots is that it only corrects when really necessary, which encourages active learning. Similar to a physiotherapist, who only helps patients with what they can’t do, this apparatus only supports those movements that patients cannot carry out themselves. It does this with the aid of smart sensors and computer programmes. ‘The robot is constantly taking readings: is the patient already doing more, can I reduce the support I’m giving?’ Buurke clarifies. ‘The great thing about LOPES II is that patients can walk without feeling the robot. They can completely follow their own gait pattern. Technically speaking that’s pretty complicated. It entails countering the apparatus’ weight and slowness.’ Fleerkotte changes the settings so that Martijn can now walk without support. And the robot grinds away even more. The thud-whoosh of the motors has changed into a noise you’d expect in an old factory. ‘All these motors are really heavy,’ Fleerkotte says. ‘But Martijn feels as if he’s only carrying a light rucksack.’ The great freedom of movement and the subtle support from the robot makes patients feel as if they can almost walk normally again. That’s one of the great advantages of this robot. ‘It has a major psychological impact,’ according to Fleerkotte. ‘The feeling of being able to walk normally again is extremely motivating.’ Buurke says that ‘it’s really great to see patients coming here who can’t walk properly and know that you can change that thanks to a robot.’ ■

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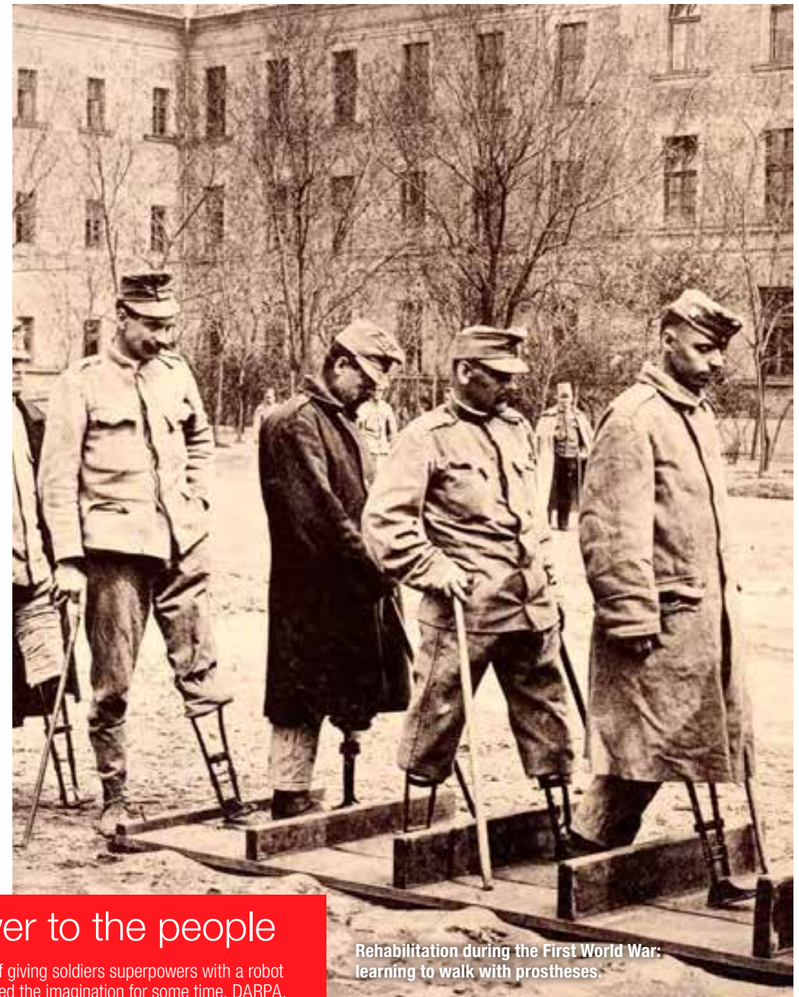
MORE INFORMATION

vimeo.com/94946064: video that shows the walking robot in action.

Paraplegic walks again

The 2014 World Cup was kicked off by a 20-year-old Brazilian paraplegic. He was able to walk thanks to what’s known as an exoskeleton, a kind of robot suit that he was able to control with his thoughts, via an electrode cap. The exoskeleton is very similar to the harness used in a walking robot, except the motors are directly attached to the harness. It is mainly intended for patients that have no chance of learning how to walk again through rehabilitation. The research into this innovation is still in an experimental phase. The movements that you can make in this suit are still very limited. And it costs patients a great deal of energy to use the apparatus. So that, and the high cost, means that exoskeletons have little appeal as a practical aid at the moment. The partially paralysed British woman Claire Lomas is the only person thus far to have used an exoskeleton in daily life to move about. She had to cough up 54,000 euros for it, which was raised by friends. In 2012 she participated in the London marathon in her robot suit. It took her 17 days.

Claire Lomas finished the London Marathon thanks to an exoskeleton.



Rehabilitation during the First World War: learning to walk with prostheses.

You can lift ten times more weight than usual wearing the HAL robot suit.

Power to the people

The idea of giving soldiers superpowers with a robot suit has fired the imagination for some time. DARPA, the American army’s research institute, is working on robot suits that make it easier to lift and move objects. But the same technology can also be used to support people who have lost the strength of their arms or legs due to illness or age. A Japanese company called Cyberdyne developed the robot suit HAL for this purpose. Sensors in the suit receive signals that the brain sends to the muscles to get them to start working, after which the suit uses the signals to control small electric motors on the arms or legs. It enables the person wearing the suit to lift ten times the normal weight. Roessingh Research and Development, a company from Enschede, is developing the IronArm with a Swedish technology company. The innovation is meant to support the hands and arms of the elderly so they can carry out daily activities independently. It uses a soft material instead of a robot-like skeleton. A glove strengthens the grip on objects, and an arm piece provides support when lifting the arm.

Debt to war

Ironically, we owe the most important advances in rehabilitation technology to wars. During the First World War, new weaponry ensured that soldiers returned home with less than four limbs. That accelerated the development of prostheses. During the Second World War, the Jewish neurologist Ludwig Guttmann (1899-1980), who had fled to England from Germany, laid the foundation for the treatment of paraplegic patients. In 1944 he was put in charge of a hospital where British war veterans were treated for severe back injuries. In those days, few paraplegic patients lived long. It wasn’t so much the wounds themselves that caused them to die, but more the complications, such as inflammation of the kidney or infected pressure sores. Guttmann recognised how important movement was to help these patients. The competitions for the handicapped that the doctor organised to motivate his patients eventually evolved into the Paralympics.

High-flyers in the world of science

NWO IS INVESTING IN SCIENTIFIC TALENT. IT AWARDS GRANTS THROUGH SPECIAL PROGRAMMES TO BOTH YOUNG AND EXPERIENCED SCIENTISTS SO THEY CAN SET UP THEIR OWN RESEARCH.

TEXT: ANTJE VELD / PHOTOGRAPHY: ADRIE MOUTHAAN

Origins of life

Who? Edith Fayolle (29), postdoctoral researcher at the Harvard-Smithsonian Center for Astrophysics in the United States. **Funding?** A Rubicon fellowship: this programme enables recently graduated PhD scientists to gain experience at a top foreign institute.

What kind of research do you do?
'I am doing research on molecules in space, particularly where stars and planets form. I am hoping it will help me to understand under which circumstances life is created there. So actually the real question is: how special are we? Because we already know which molecules are needed to create life on earth. What this means practically speaking is that I spend a great deal of time in the laboratory, where we try to imitate circumstances in space. I also do astronomical observations with telescopes.'

What is the most important discovery in your field in the past five years?
'The results that the ALMA (Atacama Large Millimeter Array, ed.) telescope in Chili has delivered since it became fully operational in 2013. Thanks to this telescope in Chili we can study places in the universe that we could not observe in the past. This provides us with new information that will help to advance my research. For example, researchers recently used the ALMA to observe for the first time the presence of extremely complex molecules, such as methyl cyanide, around a young star. This indicates that the circumstances under which the earth and the sun formed are not unique in the universe.'

What does this period mean to you personally and for your research?
'Working at a top foreign institute means working in a streamlined environment. There is sufficient funding and an extremely competent staff. That has enabled me to focus completely on the science. What has influenced my research most are the meetings with top scientists during coffee breaks or after lecture. I had the opportunity to learn unique experimental techniques, which will be valuable for the rest of my career. My time in America has also broadened my view of all the fields that my research can have an impact on.'

Edith Fayolle: 'What has influenced my research most are the meetings that I have had with top scientists.'

Adult criminal

Who? Vere van Koppen (30), assistant professor of criminology at VU University Amsterdam. **Funding?** A Veni worth up to 250,000 euros that enables recently graduated PhD researchers to develop their research ideas.

What kind of research do you do?
'I do research on crime and the life-course. I look at the life-course of offenders and how this relates to their criminal activities. For example, I study the type of offence that someone commits and when it occurred during that person's life. I also look for correlations with other life events, such as marriage or finding a job. For example, is someone less likely to slip up if they're employed?'

What are you going to do with the Veni money?
'Almost all the research in the Netherlands in this field focuses on young criminals, the idea being that crime is something that starts in someone's youth. But different statistics have shown that three out of four criminals in the Netherlands have never been in trouble with the police or the criminal justice system before the age of eighteen. That's why I am studying perpetrators who only fell into crime once they were adults. I try to paint an accurate picture of these criminals' profile and their reasons for getting into crime using available police data and by interviewing the criminals themselves.'

Who will benefit from this research?
'This research is useful for the police. Their approach mainly targets young criminals, who generally commit different crimes than adults. Young people commit more street crime and violent crimes, while older people usually commit fraud and organised crime. If we can come up with a better way of explaining why adult criminals slip up, then the police will stand a better chance of combatting them. When young criminals are released from prison, for example, they receive help finding jobs because we know that works well with them. But we still have no idea whether that's the case with adult criminals.'

Vere van Koppen: 'We want to know what works well to keep adult criminals on the right path.'

High-precision atom laser

Who? Florian Schreck (43), professor of experimental quantum physics at the University of Amsterdam. **Funding?** A Vici grant worth up to 1.5 million euros that enables senior researchers to set up their own research group.

What kind of research do you do?
'I am developing an atom laser. Contrary to a "regular" optical laser, the beam consists of atoms instead of light particles. Making an atom laser is not easy. To succeed, you have to use a special technique to cool down the atoms. For a long time, this could only be achieved in two steps, which makes it impossible to build a device with a continuous laser beam. But now I have developed a technique that makes it possible. I intend to build one of these continuous lasers with my team.'

What can we do with this laser?
'It can be used to make extremely precise measurements. For example, you could develop the most accurate clock ever. When the temperature changes in a room, old-fashioned pendulum clocks become increasingly inaccurate. Depending on the clock and the temperature difference it can deviate as much as a few seconds a week. The best clocks in the world use atoms instead of a pendulum to measure time. Atoms are much more accurate, because they are exactly the same all over the world and are barely affected by temperature. Researchers in Boulder, Colorado recently built an atomic clock that will only deviate one second over the entire lifespan of the universe. The atom laser we are working on should allow us to construct even better clocks.'

What inspired you to get into this field?
'I was already building robots and creating laser shows as a child. I knew from a very young age that I wanted to do something related to science, and yet I was interested in just about everything. Then someone recommended that I choose physics, because it draws on knowledge from many different fields.'

Florian Schreck: 'The atomic laser can be used to make extremely precise measurements, for example in the most accurate clock ever.'

Enterprising journalists

Who? Tamara Witschge (38), Rosalind Franklin fellow in media and journalism studies at the University of Groningen. **Funding?** A Vidi grant worth up to 800,000 euros that enables experienced researchers to set up their own line of research.

What kind of research do you do?
'I am studying entrepreneurial journalism. Journalism and the provision of information are extremely important for our democracy. During economic crises, journalism also tries to find new revenue models. Entrepreneurship is becoming increasingly important. Not only in the field of journalism, but also in education. In addition to producing news, journalists are now expected to sell it as well.'

What are you doing to do with the money?
'Research on journalistic entrepreneurship focuses mainly on financial aspects, and views entrepreneurship mainly as the grasping of opportunities. But we still know little about their often uncertain daily working practices. I'm going to look at what an entrepreneurial journalist or freelancer does, what recently graduated journalists expect from the profession and which business models they're going to use to make a living. It's an economic subject, but I'm going to approach it from a humanities perspective to emphasise the human aspect of journalism. I'll be using questionnaires and will be interviewing journalists. As part of the project, two PhD students will start their own journalistic company and record their experiences and feelings in a diary.'

Who will benefit from your research?
'We are going to publish a book with portraits that shed light on what entrepreneurship in the creative sector means at a human level. Research from the US has shown that the number of burn-outs among journalists is rising quite rapidly. Often the people around entrepreneurs are affected as well. The journalist may have to rely on their partners in the beginning, to support them financially, for instance. The book and workshops for starting journalists should provide insight into how people sustain themselves in this precarious industry.'

Tamara Witschge: 'Two PhD students will start their own journalistic company and record their experiences and feelings in a diary.'

Nine examples of instructive research

Better learning

From the alphabet song by way of ‘Richard of York gave battle in vain’ or ‘Roy G. Biv’ to the Pythagoras theorem: between the ages of five and sixteen, children are inundated with all kinds of information. Unsurprisingly, a great deal of research has been done on the most effective ways of learning. Following are nine lessons from science.

TEXT: ANOUK BROERSMA

1 Mathematical hurdles

WHAT WAS THE FOCUS?
Dutch preschool children’s arithmetic skills

HOW?
Dutch and English children were tested on their ability to choose the larger of two numbers. For example, if the numbers 13 and 24 appeared on one side of the computer screen and 69 on the other, they were asked which was the larger: 13 plus 24 or 69?

WHAT WAS DISCOVERED?
‘Preschool children can already do this task as they are clearly performing above chance level,’ says cognitive psychologist Iro Xenidou-Dervou from VU University Amsterdam. ‘But this applied less to Dutch children than English, though they had similar backgrounds.’ It’s down to language, says Xenidou-Dervou. English speakers say, for example, ‘sixty-nine’. As soon as they hear ‘sixty’, they know approximately how big the number is. But Dutch speakers say ‘nine and sixty’. So they first hear ‘nine’ and have to put that briefly on hold before they can estimate the number’s size. That’s an extra step in the thought process. ‘Learning maths is like running hurdles. And Dutch children have more hurdles to overcome.’

WHAT CAN WE LEARN FROM THIS?
Xenidou-Dervou believes that Dutch children would benefit from already learning bigger numbers in preschool. Not only to keep up with their English peers, but also for another reason that emerged from the research, namely that preschool children who performed better on the approximation task also had higher average scores in mathematics achievement when they reached grade 2.

HOW DOES THIS RESEARCHER HANDLE THE DUTCH WAY OF NAMING NUMBERS?
Xenidou-Dervou initially struggled with it as well. ‘When the cashier expressed an amount with inversed numbers, I was a bit perplexed at first.’

2 Multilingual readers

WHAT WAS THE FOCUS?
Reading comprehension at pre-vocational school and the link with multilingualism

HOW?
Educational researcher Roel van Steensel (formerly the University of Amsterdam, now Erasmus University Rotterdam) tested hundreds of pupils’ reading comprehension, vocabulary and multilingualism. Moreover, he also monitored about fifty pupils over a three-year period.

WHAT WAS DISCOVERED?
Twelve to thirteen-year-old multilingual pupils performed worse than the monolingual ones. Not because they’re multilingual but because they have a smaller vocabulary. Close that gap and they would probably be better readers than their monolingual classmates, says Van Steensel. ‘The two groups did start to level out a bit after three years. Everyone’s reading level improved as the pre-vocational education progressed, but that level increased more dramatically with the multilingual pupils. Thanks to a growing vocabulary.’

WHAT CAN WE LEARN FROM THIS?
Of course it can never do harm to boost pupils’ vocabulary. But Van Steensel believes that it’s also important to make reading more fun. ‘Some pupils show a great deal of resistance. During our reading test, some of them said things like: “Why should I bother, I can’t do it anyway?”’

SO HOW CAN WE PUT FUN INTO READING?
Giving children more freedom in what they read will probably help. For example, Van Steensel knows of a school that doesn’t use a mandatory reading list. The pupils choose texts themselves about subjects that interest them. One boy who hated reading went for quite a technical book about mopeds, for example. ‘The teacher didn’t know the first thing about the subject. But the boy could explain everything in the text. So for him it turned out to be a positive learning experience.’

Sometimes children get more out of a story than an explanation

3 Making films in your head

WHAT WAS THE FOCUS?
Experiencing what you read: immersing yourself in the story instead of indiscriminately absorbing words

HOW?
Menno van der Schoot, educational researcher at VU University Amsterdam, tested three training methods with his research group to help eight and nine-year-old students 'experience' what they read. 'Children learned how to make narrative films in their head,' says Van der Schoot. The first method, which stimulates the imagination, allows pupils to let their senses go wild. 'For example, if the story's about having fun in a swimming pool, you can see the blue water, smell the chlorine and hear someone splashing in the water.' The second method teaches children to connect stories to prior knowledge. Imagine reading this sentence: 'The criminal stabbed the victim with a weapon.' This sentence begs the question: what kind of weapon? 'It could be a screwdriver,' says Van der Schoot, 'but chances are, it's a knife.' The third method taught children to keep thinking about whether they still understood everything while they were reading, whether it all still made sense. They practiced by reading stories in which something wasn't quite right, such as: 'The boy was playing with his model trains in the attic, when he heard a voice from upstairs say that dinner was ready.'

WHAT WAS DISCOVERED?
After a month, the children had clearly improved in two of the three reading strategies: connecting stories to prior knowledge and keep thinking about whether you understand what you're reading. Imaginative skills had not improved after the training. One reason for that may be that these children already scored well in imaginative power. 'So there was less room for improvement there,' suggests Van der Schoot. What did improve with all three methods were the scores for reading comprehension on the Dutch national placement exams for secondary school.

WHAT CAN WE LEARN FROM THIS?
Van der Schoot hopes that teaching methods will focus more on experiencing what you read. 'Of course, sometimes people say things like "just imagine you're there", but that's where it often ends. We have developed special exercises to take it a step further.'

4 Drawing diagrams of sums

WHAT WAS THE FOCUS?
Arithmetic problems wrapped in stories

HOW?
Educational researcher Anton Boonen (VU University Amsterdam and Windesheim University of Applied Sciences in Zwolle) studied how eleven-year-old children deal with arithmetic sums. 'To solve a math word problem, children first have to understand the text. That doesn't always go well,' Boonen says. He expects it to improve if they draw diagrams of their sums.

WHAT WAS DISCOVERED?
Only 35 per cent of the children resorted to drawing, and not always well. Take the following question: how many trees will fit along a road 15 metres long if the trees are 5 metres apart from each other? 'It's pointless to just sketch a tree,' says Boonen. 'What you need to do is draw the trees in relation to one another.' Children who were able to do that well, solved the problems almost six times more often than other children.

WHAT CAN WE LEARN FROM THIS?
Education has to focus more on visualising math word problems, preferably already in pre-school. 'The kids can work with blocks there, which you can then replace with drawings of blocks when they're in elementary school. Older children will eventually do these visualisations in their head.' Teaching this method could be tricky. Boonen has discovered that some teachers find it quite difficult themselves to think up good drawing examples.

HOW GOOD WAS THE RESEARCHER AT MATHS WHEN HE WAS YOUNG?
Not bad at all. 'As a child I also visualised sums in my head. On my own, though, and not because we were being taught to.'

5 Think first, then act

WHAT WAS THE FOCUS?
The neglected child of primary education: writing skills. From grade 4 to 6 children barely improve their skills when it comes to writing texts.

HOW?
Education specialist Monica Koster and psychologist Renske Bouwer from Utrecht University designed a teaching method called *Tekster* (Texter in English). 'If you let a child do as he pleases, he'll start by simply writing, then stop to think for a second, then continue to write.' Koster says. 'Until he has nothing left to say. Of course, that doesn't produce great texts.' *Tekster* teaches grade 4 students to first think about what they want to write and only then pick up their pen. In the following two years, they learn how to critically review their scribbles.

WHAT WAS DISCOVERED?
Those using *Tekster* clearly became better writers. And how! 'On average, half a year of progress was made in eight weeks' time.'

WHAT CAN WE LEARN FROM THIS?
The researchers would like nothing more than to see *Tekster* become the norm. Not only for language lessons but also for writing papers and reports. Or simply for children to use to write Harry Potter-style stories in their free time, like one of the ten-year-old pupils did.

WHAT DID THE BUDDING WRITERS THINK OF IT?
They really enjoyed it. Koster cites an example: 'I was in a class where pupils were folding paper planes and then had to write instructions on how to fold it. That was difficult, but we had a lot of fun.'

6 Children's literature and maths

WHAT WAS THE FOCUS?
Learning maths through picture books

HOW?
Eighteen kindergarten classes participated in this research. Nothing changed in half of the classrooms, while the others got a shared picture book reading programme. 'A good story almost always has some maths in it,' says Marja van den Heuvel-Panhuizen, professor of mathematics education at Utrecht University. At least if you think beyond counting: in one book, the children learned to understand cross sections as a doll was flushed down the toilet. They followed the doll as it travelled through the sewage pipes in a cross section of the house.

WHAT WAS DISCOVERED?
After three months, the maths scores of the classes that were involved in the picture book reading programme had increased 22 per cent more than the other classes.

WHAT CAN WE LEARN FROM THIS?
That we need to read aloud more. It can teach kindergarteners things that would normally be over their heads. 'It would be too difficult to give them a straight explanation of what a cross section is,' says Van den Heuvel-Panhuizen. 'But children do understand when it's in a story.' They'll get to the bottom of it because they want to know where the doll ended up.

DOESN'T THE TEACHER NEED TO GIVE AN EXTRA EXPLANATION?
As little as possible. Let the story do the work. Children are creative thinkers. 'A teacher read a story about a princess with a long ponytail, and there was a picture of the hair rolled up around her. The children started walking in circles to show how long her hair was. That's another way of describing length.'

The notion that weak readers can't handle more than ten words per sentence is nonsense

7 Memory training

WHAT WAS THE FOCUS?
The working memory of counting preschoolers

HOW?
One group practiced with numbers, while a second group were given working memory training tasks. 'The working memory training involved games like "I'm going on vacation and this is what I'll bring…,"' says developmental psychologist Ilona Friso-van den Bos (Utrecht University). All the children did a working memory and a number sense test before and after the trainings. Their comprehension of numbers was tested by doing a task in which the children had to put different numbers in order on a number line.

WHAT WAS DISCOVERED?
According to the theory, working memory training not only improves memory but also the skills that require children's working memory, such as number comprehension. But the training did not generalise towards these skills. The number comprehension training was more effective than the working memory training. One thing is undisputed: there is a link between the performances in the number line task by preschool children and their maths skills two years after that.

WHAT CAN WE LEARN FROM THIS?
So teachers don't have to take working memory into account when teaching preschoolers how to work with numbers? Not quite true, says Friso-van den Bos. 'You mustn't overburden children. Working memory always plays a part in the background.' If you ask preschoolers a question about counting that requires them to remember too much, then it may appear as if they don't understand numbers, although the problem is that the storage space in their heads is briefly full.

WHAT DID THE TEST SUBJECTS THINK OF IT?
At that age they're itching to work on tasks. 'When I came in, the children were shy sometimes, but it didn't take long for them to join in enthusiastically,' says Friso-van den Bos.

8 Fact versus fiction

WHAT WAS THE FOCUS?
Stories and conjunctions in reading material

HOW?
For her PhD research at Utrecht University, linguist Gerdineke van Silfhout gave students from all levels of secondary school digital texts, for example about the crisis in the 1930s. While students read, their eye movement was monitored, and afterwards they answered questions about the text. Some texts contained conjunctions, while others did not, and some texts told a story, while others did not: version one simply described the causes of the crisis, and version two told the story through the eyes of Kees and his unemployed father.

WHAT WAS DISCOVERED?
The texts that used conjunctions were clear winners at all levels. The questions asked in those texts received better answers. 'The eye movements also showed that conjuctions like "because" prompted students to revisit information they had already seen. So they use these words to establish a correlation,' says Van Silfhout. And in terms of factual versus narrative: 'The pupils remembered the wrong thing in narratives. They were able to remember that Kees had worn-out football shoes, but not what caused the crisis. Those who read the factual text scored higher in comprehension.'

WHAT CAN WE LEARN FROM THIS?
Conjunctions are especially absent in texts for pre-vocational students, which tend to keep sentences short. 'We have to get rid of guidelines such as "no more than ten words per sentence for weak readers." A good sentence with a conjunction can easily accommodate seventeen words.' How about stories? There aren't very many in textbooks.

HOW ABOUT LIVENING UP THE READING MATERIAL?
'Actually, pupils didn't prefer narrative texts to factual ones,' Van Silfhout says. They see reading material as something you have to learn, so by definition boring.'

9 Reading lessons in history

WHAT WAS THE FOCUS?
Train children how to read outside Dutch classes as well. Because pupils also have to read in factual courses like history and biology.

HOW?
Put thirteen-year-olds together in small groups and let them read and figure out their reading material together. Linguist Niki Moeken from the University of Amsterdam expects weak and strong readers alike to learn from each other using this method. Each group member was given a rotating role: the chairman led the discussion, the writer recorded the answers, the thinker thought out loud about what had been read, and the helper looked up words. Six school classes from all levels of secondary school used this method to do their assignments in biology, history and geography.

WHAT WAS DISCOVERED?
The students scored better in reading comprehension tests after eight weeks than the pupils who had read classical or self-chosen material. One pre-vocational class felt the new method was unnecessary. Reading was a piece of cake. 'Even their performances improved,' Moeken says.

WHAT DID THE TEST SUBJECTS THINK OF IT?
Group lessons are boring. That was the harsh judgement of students in retrospect. At the same time, they did find it useful. 'They said that they now read texts differently,' according to Moeken. And they have become diligent summarizers, something that may come in handy when studying for tests.

WHAT CAN WE LEARN FROM THIS?
We should organise more group readings in factual courses. 'Teachers sometimes have difficulty running group discussions.' But if they received training, why wouldn't you use this method in all subjects? Moeken can visualise it. 'Maybe not four hours a week, like in our research. Every now and then, pupils just want to hear what their history teacher has to say.'

A diseased artery. The yellow is accumulated fat.

Super-fast echo sheds light on arteries

An echocardiogram can be used to study the body, but that method is too slow to measure quick physical processes. Biomedical engineer Chris de Korte from the Radboud University Nijmegen Medical Centre developed an application for a super-fast echo machine that can produce 10,000 images per second. De Korte wants to use this fast echo to measure the health of blood vessels before the arteries start to visibly build up plaque. He'll do this by measuring the speed of the pulse wave through the arteries that is generated every time the heart contracts and pumps a substantial volume of blood. The more elastic and hence the healthier the blood vessel, the slower the wave – about five metres per second. Heavily diseased, unhealthy arteries allow the wave to shoot by at fifteen metres per second. These waves are too fast for a normal echo, but not for De Korte's echo.

Blood is pumped through the artery with every heartbeat.

Vitamin deficiency can wipe out bacteria

If bacteria are in an environment with lots of vitamins, why should they waste energy fabricating vitamins themselves? Indeed, many microbes have made this discovery already and as a result lack the genes to produce vitamins. What they do have, though, are pumps in their cell membranes that absorb useful substances. Biochemist Dirk Slotboom from the University of Groningen is studying these pumps and his work has already been mentioned five times in *Nature* in two years. His research could have major consequences. Because different bacteria have different pumps, switching off the right pumps could cause a specific bacteria to die from a lack of vitamins. With so many pathogenic bacteria around, that's an interesting new development for combatting them.

This bacteria, *Neisseria mucosa*, can cause endocarditis, the inflammation of the inner layer of the heart and heart valves

Groups important factor in bullying

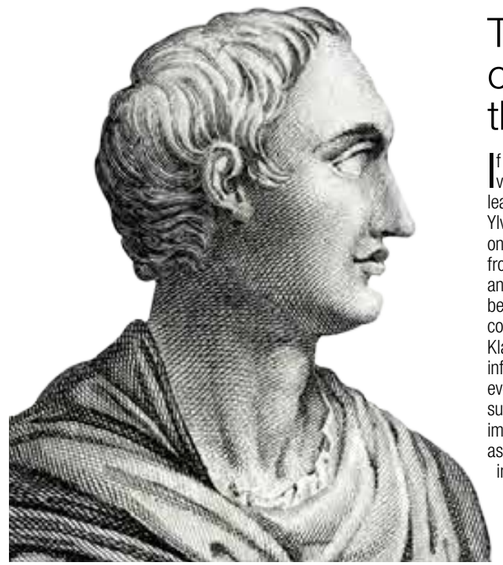
Being bullied is one of the most unpleasant things that can happen to a student. Research conducted by sociologist Gijs Huitsing at the University of Groningen among students from the ages of eight to twelve has increased our understanding of who bullies and who gets bullied. So what's the verdict? School classes consist of groups, and basically all pupils fulfil several different roles in these groups. Some students are bullied by a single person, but they in turn may bully other students themselves. The groups themselves are important too. If someone in a group is bullied, then the other members of that group will often defend that person. They wouldn't if a classmate from another group is the target. Huitsing's research exposes the dynamics of a school class. Teachers can use this information to intervene more specifically against bullying.

Victims of bullying can be bullies themselves in a different situation or other group.

Smart grid could be smarter

In the near future, we'll all be on the 'smart grid', a smart power network that was created to generate and distribute local electricity. But according to software engineer Hermen Toersche from the University of Twente, companies are using the wrong electronic systems to connect houses to the electricity network. The smart control boxes that have already been installed in some new houses are of the same quality as internet modems, for example. And they tend to malfunction or break down altogether after a year. It would cost far too much to produce a sturdier control box similar to the ones that the rest of the electricity network runs on. Which is why Toersche developed software for an interim solution during his PhD studies: a box that's a bit more powerful than the present meters, and yet affordable. So it has a longer life but doesn't cost an arm and a leg.

A smart power network is a lot more sustainable.



Tacitus: more commentator than historian

If there aren't many sources upon which to base your view of antiquity, then it's important that these at least are accurate. A specialist in classics and history, Ylva Klaassen studied the work of Tacitus (56-120 AD), one of the leading but also most unreliable historians from the Roman Empire. He regularly distorted facts and confused years. Klaassen discovered why. She believes that Tacitus is really more of a political commentator. By analysing his narrative form, Klaassen discovered that he withheld or altered information to make a point. In his texts, he cunningly evoked the same atmosphere for different situations, such as imperial successions. He thus created the impression that one emperor was just as good or bad as the next. These tricks enabled him to convey his interpretation to the reader as if it were the truth. That gave him credibility and influence.

As a commentator you enjoy more freedom regarding fact than as a historian.

More accuracy with fewer animals

Improve your research and win an award from the Dutch Society for the Protection of Animals. This welcome windfall is exactly what happened to skin biologist Sue Gibbs from VU University Medical Center and ACTA for her work on innovative research methods. Gibbs was looking for a new way of studying human skin diseases. Mice were not suitable because they are too different from humans. Gibbs developed what is called the skin-on-a-chip', in which different kinds of cells are placed together in a device or culture chamber where they can react with each other, just as in real skin. The advantage of these chips is that more than one can be run in parallel if the research requires it. Gibbs wants to eventually link other organs to her skin model by connecting various chips. She can use this model to continue her research without having to use animals anymore.

Seabed full of electric bacteria

Our ocean floors are full of bacteria that can conduct electricity over a distance of several centimetres. That's a huge distance for microorganisms and a thousand times further than we thought possible. This discovery was made by Filip Meysman, researcher and marine biologist at the Royal Netherlands Institute for Sea Research. The electric bacteria use a reaction between oxygen and sulphide to harness energy, but because oxygen is found in seawater, and sulphide several centimetres beneath the seabed, that distance has to be bridged. To do that, the bacteria form a string of cells that transmit an electrical current from one cell to the next. Meysman's work could lead to new bio-electrical materials and applications.

Entire 'electricity cables' line the seabed.

Sometimes a conflict situation can help to make groundwater available as quickly as possible.

Conflict as catalyst

The political establishment has its hands full with issues such as security and counterterrorism in conflict countries. It's not surprising then that other matters, such as groundwater management, fall by the wayside. With his company MetaMeta and the Delft University of Technology, geographer Frank van Steenbergen studied the effect of conflict on groundwater management in Yemen, Ethiopia and the Palestinian territories – countries where groundwater is crucial for agriculture and drinking water. Conflict is not necessarily bad though: sometimes it brings attention to issues such as groundwater. 'The excessive use of groundwater, especially in agriculture, is often a dormant problem,' says Van Steenbergen. 'Because there is no acute need, there is little cooperation or coordination regarding groundwater management, so water supplies continue to drop. Conflict often acts as a wake-up call in these areas, prompting people to look for solutions.' Van Steenbergen founded the Treasure Foundation, which aims to make groundwater a higher political priority.

All together now

Who didn't point their iPhone to the heavens in 2013 to capture the blue sky? Many people that year participated in the iSPEX study to measure particulates. Instrument scientist Jeroen Rietjens from the space research institute SRON has now confirmed that the measurements can be used. To gauge whether the iSPEX measurements differ from the data generated by 'professional' measuring equipment, Rietjens decided to compare them. It turns out they correspond. The nice thing about iSPEX is that the measurements with all these phones provide high-density data. The limitation, however, is that contributors have to be willing and able to conduct their measurements day in and day out. That's why SRON is trying to get an instrument with comparable technology onto a satellite, in order to create a particulates map of the world.

The presence of police on an enjoyable night out can actually frighten people.

Effect of riot police van varies

For many, a quick visit to the pub is good fun, but the mood can change if the first thing they see when leaving is a riot police van. Human geographer Jelle Brands obtained his PhD at Utrecht University for his research on how safe people feel when they're out on the town, and what role surveillance plays in this. He discovered that video surveillance doesn't make revellers feel safer when they're out. A police presence can increase people's sense of security when people feel threatened. But if people are having a good time, a police presence can also evoke a sense of insecurity because it suggests that there may be trouble on the horizon. That's why police should be deployed according to the circumstances. Luckily Brands did notice that people generally feel safe when they're out on the town.

‘Religion is something people do’

Lived faith

The world is changing, and religion is playing a prominent role in this process. Good reason to study religion from another angle: practice. Birgit Meyer, professor of religious studies at Utrecht University, is a leading proponent of this approach. In 2015, she received the NWO Spinoza Prize worth 2.5 million euros.

TEXT: BERRY OVERVELDE / PHOTOGRAPHY: ADRIE MOUTHAAN

BIRGIT MEYER, professor religious studies at Utrecht University, received the 2015 NWO Spinoza Prize.

How did you hear the news?

‘I received an email from NWO chairman Jos Engelen, asking me to call him. I thought, “Hey, I wonder what he wants from me?” So I called him right away. He said: “I’m pleased to congratulate you as a laureate of the Spinoza Prize.” I had to sit down when I heard that. Me? I never really felt that my work was making that much of an impression in the Netherlands outside my fields, which are anthropology and religious studies. But perhaps I was wrong about that. I’m also honoured that I’m receiving such recognition as a German, albeit one who has lived in the Netherlands for thirty years. So I was pleasantly surprised.

‘I got right back to work after that, because I still had a pile of things to do. But my husband and I did celebrate with a glass of white wine that evening.’

Why did you start doing what you do?

‘I initially studied pedagogy and religious studies in Bremen. I wanted to become a teacher in religious education and education for children with special needs. But these studies increased my interest for other ways of thinking, and living. That’s what prompted me to study anthropology. I conducted research on contact zones, where people from different cultures converge. Europeans and indigenous peoples in West Africa for example, where I did a great deal of research, especially in Ghana. I was interested in why people in Africa were prepared to give up their religion for Christianity and how they handled their new religion. And also how they developed a new self-image within the context of new religious representations.’

How did a German end up in Ghana and the Netherlands?

‘Africa had already fascinated me for a long time. When I was still studying in Bremen in 1983, I went to Togo to help build a school. That was in a village of the Ewe, an ethnic group in West Africa. I became fascinated when I saw that they not only worshipped indigenous gods, but that they also had a church. As it turned out, the church had been built in the nineteenth century by a missionary society from Bremen, of all places. When I got back to Germany, I immediately began finding out more about the society, and also why indigenous peoples had accepted Christianity.

‘I went to Togo one more time, to complete my pedagogy studies with research on how young people envision the future. I realised that I didn’t really understand what was going on there, and that as long as I didn’t study anthropology I wouldn’t have a good way of becoming part of this other cultural reality. And because Germany was quite old-fashioned in the area of anthropology, and I expected to find, and did find, a more open society in the Netherlands, I decided to study here, in Amsterdam. Right from the start, I told myself that I would go back to the Ewe and study the missionaries’ impact. Which is what I did, not only in Togo, but also in Ghana, were the Ewe also live.’

How does your anthropological background help you to study religion?

‘Anthropologists go for the lived reality. They try to get under the skin and into the heads of the people they are researching. That’s useful when you’re trying to understand a world that is becoming increasingly diverse, in which we are confronted with more and more diversity, with people who are different. So anthropological research skills are extremely important for understanding one’s own society. That’s interesting because when anthropology began it was mainly about understanding and documenting people in other societies.’

Is religion making a comeback?

‘I don’t think it has ever been away. I do think religion is sometimes more visible and sometimes less so.’

Why are religious studies especially important now?

‘Until about the 1990s everyone assumed that religion would become increasingly unimportant, that religion would become more and more of a private matter in the face of growing modernisation and development, and that it would eventually even vanish. But this assumption was totally mistaken. In the past twenty years, we’ve been confronted with a highly complex religious domain, with the coming of migrants with a Muslim but also a Christian background. The latter are often from Pentecostal churches, which are very popular in Africa and centre on immersion in the Holy Spirit. But we are also having to deal with secularisation, which is creating a need for new forms of spirituality. Religion has certainly been at the heart of the public debate since 9/11. The big ▶

‘I don’t think religion ever went away. It’s just less visible sometimes’

question now is how we are going to manage to live together in a society that has become highly diverse religiously and culturally, whether you like it or not.’

So why is it so beneficial to study religion from the perspective of practice, as you do?
‘It’s interesting that religious conflict is often not about ideological doctrine but actually about very concrete issues. Such as whether or not to depict the Prophet Muhammad in political cartoons. We are having serious discussions about religious intervention on our bodies, such as circumcision. About how to deal with religious buildings, such as empty churches, and so on. It’s always about how religion is used in practice. It’s about how we deal with things, how we deal with images, with the body. That’s why, if you want to understand the diversity of religion and the conflicts that arise from it, it’s important to have a concrete, practice-oriented approach. Religion is something people do. Even if it feels counter-intuitive, because when people think of religion they think of something divine, something intangible.’

Is religion therefore more than ‘the word’?
‘There used to be much more emphasis on the word. When I started doing research, I was still strongly focused on text. It’s with good reason that my first book was called *Translating the Devil*. But I’ve come to realise that you have to view religion as a multimedia phenomenon. Images, the body, objects and so on: just like text, they are “media of religion”. People use them to make the intangible imaginable and palpable. They can engender strong sensory experiences, what I like to call sensational forms. Whether it’s an image that evokes an emotion, or the feeling of being immersed in the Holy Spirit like in the Pentecostal church: these sensational forms ensure that people experience the intangible in religion as something real. And these sensational forms are precisely the reason why religion is still doing well.’

Back to the prize. Why do you think that you were singled out as a laureate?
‘That’s a difficult question of course. But I do think that I’m passionate about my work and that I convey that in my teaching, lectures and publications. And I’ve done research in a number of other areas that has had an impact, including media and religion, the Africanisation of Christianity, Pentecostal churches and film in Africa. Moreover, I bring together different approaches to religious research: research that focuses on the body and on concrete, material objects, and not just ideology. I think that my interdisciplinary approach appeals to people, the combination of elements from religious studies, anthropology, media studies and other academic disciplines. And religion is causing a lot of controversy at the moment, so I think that plays its part as well.’

How important is a prize like this?
‘It’s a huge honour, an acknowledgement of my work, even though I am a team player. I definitely do not consider this as a prize only for me. It’s also an acknowledgement of a discipline. For religious studies, the anthropology of religion. Our discipline went through a rough time in recent years at Dutch universities. It suffered from restructuring, from downsizing, and so on. That’s why my receiving this prize is such a windfall for religious studies. In addition, raising funds for research has become increasingly difficult. The prize makes it possible for me to set up a genuinely large project, without my having to constantly worry about how to fund it. That’s why this prize comes with a huge sense of relief. Now I can concentrate more fully on the research itself. I think that’s fantastic.’

Do you already know what you’re going to do with the money?
‘Nothing is definite yet. But in any case I want to continue and build on my present work. For that I want to talk to people from my discipline, but also people from other academic fields that deal with religion. I want to further develop the material approach to religion.
‘What’s very important to me, aside from an interdisciplinary approach, is a trans-regional perspective. So not research that focuses solely on the Netherlands, but research that views religion as a global phenomenon. I want to work with researchers from outside Europe and the US. I want to make it possible for young researchers, particularly African ones, to work with us on a large research project on religious diversity. I want that project to revolve around a number of major global clashes, so-called iconoclashes, about religious images. That used to be a bone of contention between Protestantism and Catholicism, but new forms of this have emerged, including the way that Islamic State is dealing with cultural heritage. But there are other clashes. I want use my view of religion as a multimedia phenomenon to study several of these clashes – by discovering how different traditions experience and live religion. This won’t make differences disappear, nor can you solve the tensions that arise from them. But you can foster understanding. But I want even more. I have plans to develop teaching materials. And an introductory book about religious research in which perspectives from “the south” feature more than now.’

No lack of plans.
‘Yes, that’s right, I have many plans. I’m really enthusiastic about this prize, also for my discipline. The recognition has given me a boost to continue, even more systematically, with this work.’ ■

berry.overvelde@quest.nl

Who is Birgit Meyer?

1960: born on 21 March in Emden, Germany.
1985: graduates from the University of Bremen, in pedagogy and religious studies.
1990: graduates cum laude in cultural anthropology at the University of Amsterdam (UvA).
1995: obtains her PhD at UvA, cum laude. Becomes university lecturer and later senior lecturer at UvA.
2000: receives a PIONEER Award from NWO for the ‘Modern Mass Media, Religion and the Imagination of Communities’ research programme.
2004: appointed professor of religion and society, and professor of cultural anthropology at VU University Amsterdam.
2006: becomes co-editor of the academic journal *Material Religion*.
2007: member of the Royal Netherlands Academy of Arts and Sciences (KNAW).
2008: leads the ‘Heritage Dynamics’ research programme, funded by NWO.
2010: becomes a fellow of the Institute for Advanced Study Berlin, and Dutch programme leader for the European HERA research project, ‘Creativity and Innovation in a World of Movement’.
2011: professor of religious studies at Utrecht University. Receives the Anneliese Maier Research Award from the Alexander von Humboldt Foundation.
2012: member of the Royal Holland Society of Sciences and Humanities.
2013: Dutch programme leader of two HERA research projects: ‘Iconic Religion’ and ‘Currents of Faith, Places of History’.
2015: fellow of the Centre for Advanced Study in Oslo. Awarded the Academy Professor Prize (KNAW).

Science and business, side by side

It all adds up

New companies and science institutes are working side by side at the Amsterdam Science Park. They benefit from each other's knowledge, expertise and facilities, in what you could call good scientific neighbourliness.

TEXT: ANTJE VELD

AMOLF researchers gather around a table to discuss the instruments they use.

▲ The Science Park on the eastside of Amsterdam.

They've all converged on this small piece of land in Amsterdam: experts in physics, chemistry, biology, information technology, but also artificial intelligence. The Amsterdam Science Park accommodates various NWO research institutes and centres (see 'In this together' box). Parts of the University of Amsterdam (UvA) have established themselves here as well. And there are a number of start-ups and spin-off companies here too. The consolidation of science and industry is giving both a major boost.

Deep research

Take Tallgrass, a start-up that specialises in fibre optic technology and is pretty much the neighbour of NWO research institute Nikhef, which conducts research into the interaction between elementary particles and their structures. One of Nikhef's projects is taking place at the bottom of the Mediterranean Sea. Thousands of glass balls are hanging suspended off the coasts of Marseille and Sicily to collect data about the way in which elementary particles react with seawater (see article about neutrinos on page 52).

Nikhef was able to produce the sensors for the glass balls itself, but what it then needed was help from someone who knows something about fibre optics to extract the data and send it to the researchers on land, a hundred kilometres away. And, you guessed it, their neighbour in the Science Park, Tallgrass, had just the expertise they were looking for and so before long the two were working together.

Tallgrass supplied the fibre optics technology needed to transmit information from eighty glass balls through a single cable simultaneously, instead of through eighty cables that have to be laid out one by one. Moreover, Tallgrass searched for a manufacturer who could build a sustainable laser at an affordable price that could be used to put all that data into the fibre optics.

'These kinds of lasers will essentially last ten years,' says Reindert Hommes, co-founder of Tallgrass. 'But a project like this at the bottom of the sea is obviously going to run you a pretty penny.' Nikhef wanted a laser with a long lifespan. 'So at a certain point we went to South Korea with the laser manufacturers to find a way of extending the lifespan. Thanks to a technique that enables us to control the temperature remotely, the laser doesn't wear out as fast. That has enabled us to extend the duration of the project by five years.'

Always welcome

Of course, Nikhef could have developed the laser itself, but that would have been a lot more expensive and would have taken much longer than it has working with Tallgrass. 'We introduced Nikhef to a market that they were unable to immediately access. These processes often take a long time in Asia. Before you've had the chance to make it clear what it is you want, several months have gone by. Our start-up had already done that legwork,' Hommes explains. 'So we ensure that a study gets off the ground sooner and is effectively implemented. Businesses here at the Science Park consider being supportive an important task. And because we're all five minutes away from each other, we're always welcome to walk into each other's offices and share new products or discuss a new research idea.'

Start-ups growing fast

Tallgrass was an early bird. This start-up moved to the Amsterdam Science Park because Hommes was studying information technology there. He realised that a ▶

In this together

In 1946, NWO research institute Nikhef was the first to establish itself on what was still a barren piece of land in East Amsterdam. In the decades that followed, Nikhef's neighbours started multiplying. When the area was officially renamed the Amsterdam Science Park, things developed rapidly. Today a large number of research organisations call this seventy-acre park home, including the Advanced Research Center for Nanolithography (ARCNL) and, aside from Nikhef, several other NWO institutes such as the Institute for Atomic and Molecular Physics (AMOLF), the Institute for Mathematics and Computer Science (CWI) and the Netherlands eScience Center (NLeSC). In a few years, they will be joined by the NWO space research institute SRON, which is still situated in Utrecht. And there are many other organisations located there, such as UvA, the Amsterdam University College and about 120 businesses – from start-ups to multinationals. All in all, the science park employs about 3,000 people, and there are some 6,000 students wandering around.

EUvision's software is being used to categorise wreckage from MH17

▼ The laser lab is one of AMOLF's research workspaces. Here, a researcher adjusts the lenses of his laser.

creative location was being set up that could provide space for his new business. Many start-ups at Amsterdam Science Park today have their origins in the Ace Venture Lab, which was founded in 2013 by UvA, VU University Amsterdam, and the NWO institutes AMOLF, Nikhef and CWI (see also 'In this together' box). As an entrepreneurial student, researcher or PhD student, you can approach the lab for practical help, legal advice, office space and training. In short, all you need to give your business a flying start can be found here. Today, 34 new businesses are affiliated with the lab.

That's exactly how PhD students Bruno Dagnino, Ruben Saavedra and Enzo Angilleta ended up at Ace Ventura Lab a few years ago with their start-up Metrica Sports. These two Argentinians and Spaniard came to the Netherlands as international students, lured in part by the highly reputable Amsterdam university. Dagnino and Saavedra met each other through the Dutch Technology Foundation STW. Video producer Angilleta was a teammate of theirs on the football pitch. Their passion for research, visualisation and football brought the three together to launch their start-up Metrica Sports. Under the auspices of the Ace Venture Lab, they worked on their idea to create software that would enable football clubs to analyse the performance of their players efficiently and visualise them on video footage. Now, a year later, they have a business with two employees, an intern and a major client: Spanish football club Villarreal.

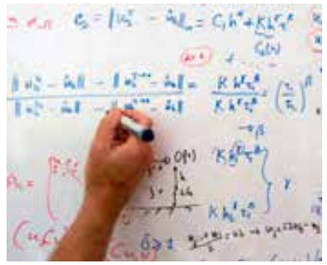


Image recognition

Another way that the Amsterdam Science Park brings together young entrepreneurs and scientists is through commercial spin-offs developed by the research institutes. One of these is a company called EUvision, which in the meantime has been taken over by a major American corporation: Qualcomm. Not coincidentally, Qualcomm is also located in the Amsterdam Science Park.

In 2010, a PhD student and the head of a research group at UvA's Informatics Institute founded this start-up, which worked with image recognition. The close ties with this research institute made it possible for many employees to work at EUvision and teach at UvA simultaneously. That was the case with Cees Snoek, associate professor in information technology and now also employed by Qualcomm. 'We do research on interpreting images by computer. We study how a computer can learn to look at what's going on in a picture or video', he says. 'We do so with deep learning technology.' The researchers developed software that can be used to teach computers who is in a photo, what the difference is between beach and mountain scenery, and how you can distinguish between a ruby-throated hummingbird and other hummingbirds. Their products have been used to categorise photo material of the wreckage of flight MH17, for example. And they're being used by the police in their fight against child pornography. 'We can teach the computer how to recognise a particular type of room, so the police will know immediately whether they've seen that room before. That helps them to gather evidence.'

High-tech environment

According to Snoek, small start-ups like EUvision could never do their work as well as they do if they didn't collaborate with the Informatics Institute. 'This is a knowledge-intensive branch of sport. Developments in image recognition are taking place at breakneck speed. If you're not right on top of the latest developments, you'll lose your competitive edge. If all you do is read articles, you'll constantly be playing catch-up. You have to be in direct contact with the people who are at the cutting edge of the technology: the researchers and professors at the forefront of the field. And they're here at the Amsterdam Science Park. It helps too that Amsterdam is internationally oriented. That appeals strongly to intelligent young people.' Snoek also commends the Ace Venture Lab and the compact location, which has the right look and feel. 'When people come here to visit a start-up, I think the high-tech environment impresses them. You can also set yourself up in a bleak industrial estate, but that's a lot less appealing to potential clients or investors.' ■

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A good example

Anyone asking anybody at the Amsterdam Science Park for a good example of a partnership between entrepreneurs and scientists will always get the same answer: ARCNL. That's a research centre where, since last year, scientists from UvA, VU, NWO and the Foundation for Fundamental Research on Matter (FOM) have been working together with ASML, a high-tech company from the south of the Netherlands that develops machinery to make (increasingly small) computer chips. Joost Frenken, director of ARCNL, explains why ASML was also drawn to the Amsterdam Science Park. 'We can provide a concrete research plan and link that to experienced researchers, and ensure that it's all organised highly efficiently. We do the fundamental research that ASML cannot manage to do, such as ultra-fast laser experiments that can produce ultraviolet light. These processes are very complex, but you need that light with its incredibly short wavelength to make increasingly small computer chips.

Altruists

For ten years now, the annual Amsterdam Science & Innovation Award is presented at the Amsterdam Science Park by Innovation Exchange Amsterdam. The award, worth 10,000 euros, goes to the most innovative idea resulting from scientific research. It has to have a profit-making business model, but the jury is susceptible to ideas that can make the world slightly more beautiful. This year, ten finalists were chosen from seventy entries, half of which came from the field of medicine. So who won? Paul Govaerts and Martine (VU). They used mathematical models and artificial intelligence to develop a way of adjusting hearing aids. They created highly accurate hearing tests and a programme that immediately adjusts the implant, without the intervention of a doctor. The Amsterdam Science Park public award was won by Jurre den Haan and Femke Bouwman (VUmc), who discovered a technique for recognising Alzheimer's disease in the eye. Using the spice turmeric, which attaches itself to the Alzheimer protein, and a special eye scanner, they make the protein visible in the eye.

The ARCNL research centre does fundamental research in the area of nanolithography. Here, a PhD student is working in one of the ARCNL laboratories.

Metrica Sports at work during a Villarreal match.

Museum collection gathering dust? It could be extremely valuable to scientists

Hidden treasures

They've sometimes been lying in an archive for a couple of centuries. The last time anyone saw them could easily have been fifty years ago. And yet old scientific collections sometimes contain hidden treasures.

TEXT: ELLY POSTHUMUS

Half a million years ago, a *Homo erectus* scratched zigzags on this mussel shell. It was probably black back then, so the zigzags would have been clearer. We know of no older lines made by a hominid.

The spotlight completely lights up the shell. This fossil mussel is almost radiating under its bell jar made of hard safety glass. It's under a safety jar for good reason: this white shell is one of the 'Rembrandts' of the Naturalis Biodiversity Center in Leiden, as deputy director for collections René Dekker likes to refer to the fossil. At first sight it looks like a non-descript shell. But if you look closer, you can decipher some thin lines that have been carved into the shell in a zigzag pattern. They were only discovered a few years ago and turned out to be half a million years old. As such, these zigzags constitute the oldest known geometric pattern made by a hominid. But before anyone saw the scratches and the shell assumed a prominent place in the exhibition, it lay there unnoticed in storage for more than a hundred years. Scientific collections contain many old items, some of which have not been looked at for years sometimes. And yet they're usually well preserved and are extremely valuable for scientists. Who originally collected all these items? And what use are these old collections today anyway?

A close-up of the scratches. Whether they symbolised anything we'll never know.

An archived world

Already in the sixteenth century, universities, explorers and tradesmen collected scientific curiosa. 'People were curious,' Dekker says. They collected anything that grew and blossomed or happened to find itself in the sights of their rifle. They collected for pleasure, to boost their ▶

New techniques are putting old animals in a new light

reputations or out of interest. For example, stadtholder William V (1748-1806) had a veritable cabinet of 'natural history' with many plants and animals. Collector scientists wanted to describe the world. 'In the nineteenth century, museums sent out expeditions with the specific aim of collecting as many plants, animals and historical artefacts as possible.' These expeditions could take years. Most countries concentrated on their own colonies. For example, the National Museum of Natural History, one of Naturalis' precursors, sent people to the Dutch East Indies to describe the archipelago's landscape and its living species. They brought back all kinds of natural treasures. Many of these items are still part of museums' collections and archives, a fact that definitely pleases today's scientists.

What did a reef look like?

'I can use items from old collections to see recent changes in nature, for example,' says Willem Renema. He's a marine micropalaeontologist at Naturalis and is studying tropical marine ecosystems, such as coral reefs. 'We want to protect coral reefs, but we don't really know what they originally looked like,' Renema says. Luckily, in addition to fossils, an abundance of live coral was collected around Indonesia in the early twentieth century as well. The expeditions also made extremely accurate descriptions of the reefs: where did the various corals grow and which species lived there? 'We use these descriptions as a frame of reference,' Renema says. The specimens collected back then can still yield information today. 'With new techniques and new knowledge, we're in a much better position to examine historical items.' Trace elements in the calcium skeleton of old coral tell us something about the concentrations of these elements in the seawater at the time, for example. Researchers can also reconstruct past climates. How? The amount of magnesium in coral skeleton tells us something about the temperature on earth. The warmer it is, the more magnesium corals take in. And the thickness of shells reveals something about the level of acidity in oceans. The more acidic the water, the more difficult it is for shellfish to develop calcium skeletons. Water becomes more acidic when there's more carbon dioxide in the air. This gas is converted into carbonic acid in the surface water. 'Acidification has probably only been around since the 1960s,' says Renema. 'The big question now is: how was it in the past? And how bad is it? Will shellfish find a way to adapt?'

Naturalis is still expanding its collection. 'We are trying to document everything as best we can,' Renema says, 'so researchers in 500 years can also look back at how things are now.'

Going, going, gone

Saving old collections is important for another reason: some items come from places where nature has vanished – because the areas have been deforested to make room for cities, for example. The species that once lived in these places have disappeared too. Sometimes they're plants and animals that aren't found anywhere anymore. Imagine they had never been documented. Dekker points out a blue antelope in the depot at Naturalis, which was driven to extinction by humans two centuries ago. This specimen was shot in 1770 and subsequently stuffed. It looks well conserved, at most a little discoloured over time. 'That's because it used to be in the light,' Dekker says. 'Now everything in the depot is in the dark under controlled conditions. But in the past, museums simply kept artefacts in attics or in front of windows.'

In addition to their physical appearance, dried plants and stuffed animals can also

The blue antelope lived in South Africa and has a blue sheen. The last of the species was shot in 1799.

This species of coral in the Naturalis collection still exists in Indonesia, but it's likely to be threatened with extinction in time.

High flyer

They were nowhere to be found, not in a single bird book. Kees Roselaar, former curator at the Zoological Museum in Amsterdam, spotted two mounted birds in a collection 1992. The unfortunate birds had been collected at 5,125 metres in western Tibet in 1929. Roselaar described them as a new species: Sillen's mountain finch. 'With more obscure creatures, such as insects, you sometimes encounter unknown species in collections,' says René Dekker, deputy director for collections at Naturalis. 'But that rarely happens with larger animals, such as birds or mammals. And if it does happen, they're usually extinct already. Which is why they were never seen again of course.' For twenty years it wasn't clear whether that had been the fate of the Sillen's mountain finch. Until a French photographer captured a few of the birds on camera in 2012 in a remote area in Tibet at an altitude of 5,000 metres. Alive and kicking.

People will view their collections differently now

▶ divulge other secrets about their lives and characteristics. They still contain DNA, says Dekker, and otherwise hair or bone analysis can reveal what an animal has eaten. Researchers can determine whether an animal's diet has changed over time, for example, because it had to adapt to a changing climate.

It's old but it's good

The Spanish brought the tomato plant to Europe from the Andes. Sometime between 1542 and 1544, the dried plant found itself in an Italian herbarium. Eventually it ended up in Naturalis. It's one of the oldest (non-fossil) collection items and carries the earliest genetic material of the tomato plant in existence. The tomatoes that we buy today in the supermarket have changed considerably through the centuries as a result of breeding. The wild version in the Andes hasn't stood still for 500 years either. So what use is this old tomato plant? Its genome clearly shows that the tomato today has lost much of its genetic diversity. This early tomato may have interesting characteristics that we would like to see in our modern versions of the fruit again one day. Perhaps we can bring back these characteristics by cross-breeding them with genetically related wild species.

This tomato in the Naturalis collection was originally cultivated by Indians. It's the size of a modern cherry tomato.

Never spotted before

Some plants, animals or objects in the archives have never been properly studied by experts. Sometimes there are previously undiscovered species in the archives (see 'High flyer' box), or scientists view them in far more detail because the focus has changed or the techniques have improved. The fossil shell with the oldest human engravings lay in the museum depot for a long time until researchers from Leiden University, among others, wanted to know whether early hominids ate freshwater mussels. The Dutch anthropologist and palaeontologist Eugène Dubois (1858-1940) found the fossil shell and other finds in the late nineteenth century on the Indonesian island of Java. They were discovered in the same deposit where Dubois also found hominid fossil bones. In order to document the shells accurately, one of the researchers photographed the mussels on graph paper, but it was only later, when he studied the photos, that he spotted the zigzag engraving. 'Detailed analyses of the engraved lines revealed that the zigzag pattern had indeed been made by a hominid. That's to say, it wasn't the work of one of Dubois' excavators or a bored curator', explains Wil Roebroeks, professor of Palaeolithic archaeology at Leiden University and one of the researchers in question. 'As it turns out, the creation of this kind of zigzag pattern was not the exclusive domain of *Homo sapiens*, as has always been assumed. *Homo erectus*, it seems, who had been there earlier and whose bones Dubois also found, already knew how to make this pattern.'

Eugène Dubois and his wife, shortly before his excavators (below) discovered the shell with the engraved lines.

That changes everything

The ramifications of such a discovery can be huge. 'I think that people with similar old collections will view their specimens differently from now on,' says Roebroeks. 'They're probably more aware that they may come across material that has been modified by early hominids. That didn't use to be the case at all.' But the discovery has other consequences too. The age of the *Homo erectus* fossils, which surfaced together with the shells, had previously been estimated at around a million years. 'But they may be just as old as the engraved shell (half a million years, ed.), because they were found in the same layer,' says Roebroeks. And that's a significant observation, as it tells us something about how and when *Homo erectus* migrated to other parts of the world. 'It's a miracle that we still have Dubois' shells, if you consider how often the collections have been moved in the past,' says Roebroeks. 'I know that there are research institutes that have been forced to throw away materials such as books and parts of geological collections. A lack of time or money, or because the institutes at stake ceased to exist or merged. Imagine, some manager could easily have said: "Keep the goodies, and chuck the shells into the nearest canal."' ■

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Label confusion

No one knew what had happened to them. Charles Darwin donated the two grey harriers, which he had collected in 1833 along with 466 other birds on the Falkland Islands, to the Zoological Society in London. But over the years, half of the birds disappeared, including the harriers. The stuffed birds were sold to dealers or had fallen apart. But in 2007, one of the harriers suddenly materialised. It had been in the National Museum of Natural History, which eventually became Naturalis, since 1860. How could that have gone unnoticed? The creature had a label that said Darwin had collected it on Malouines, the French name for the Falkland Islands, on 4 January 1837. But Darwin had been there four years earlier, in 1833. So it couldn't be one of Darwin's birds. A little detective work revealed that 4 January 1837 was the precise date upon which the bird had been delivered to the Zoological Society. So it was one of Darwin's harriers. The other one is still missing.

! MORE INFORMATION

tinyurl.com/mosselschelp : how did *Homo erectus* open a mussel?
tinyurl.com/onzevoorouders : Wil Roebroeks lecturing on the inhabitants of the Netherlands predating the builders of megalithic sites.

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Anti-freeze fish

Ice cold, that's exactly what this fish is. The Antarctic toothfish swims in sub-zero degree seawater, minus 1.9 degrees Celsius to be precise. And yet it doesn't freeze, even though non-adapted fish would be as stiff as a board, just like one on ice at a fish stall.
A protein is what's keeping Antarctic species of fish from freezing. AMOLF postdoc Konrad Meister is studying the proteins, which are found in the animals' blood, with advanced non-linear spectroscopy. They bind to tiny crystals of ice, which the animals take in via their gills, for example. The proteins prevent crystal growth and hence ice from forming in the blood. The ice crystals stay behind in the fish's body, but they're so small they don't present a problem. The proteins also have practical applications for human beings. Unilever, for example, has been using them in the US for several years to combat crystal formation in their ice cream products, and eventually the proteins could potentially be used to prevent tissue damage in cooled transplant organs.
For his research, Meister fished in the Antarctic with biologists for freeze-proof fish. The Antarctic toothfish is the preferred catch, because with a length of up to two metres it provides a lot of research material: blood.

FINAL WORD

The colours are going to fade in Van Gogh and Renoir paintings alike.

Vincent loses colour, page 38

Petrol and bat dung smell like *tjngus*.

Capturing smells in words, page 70

During eating therapy, patients can sniff the food all they like, but eating it is forbidden.

The lure of the treat, page 48

Razor clams help to keep sea sand in place.

The sands of time, page 26

Politics is often theatre, but theatre is also politics

Focus: Political puppetry, page 57

NWO on YouTube

NWO has its own channel on YouTube: www.youtube.com/NWOVenC with hundreds of videos and animations about Dutch scientific research. From smart clothing and revolutionary techniques to conserving art and new findings in archaeology and Dutch research on Antarctica.

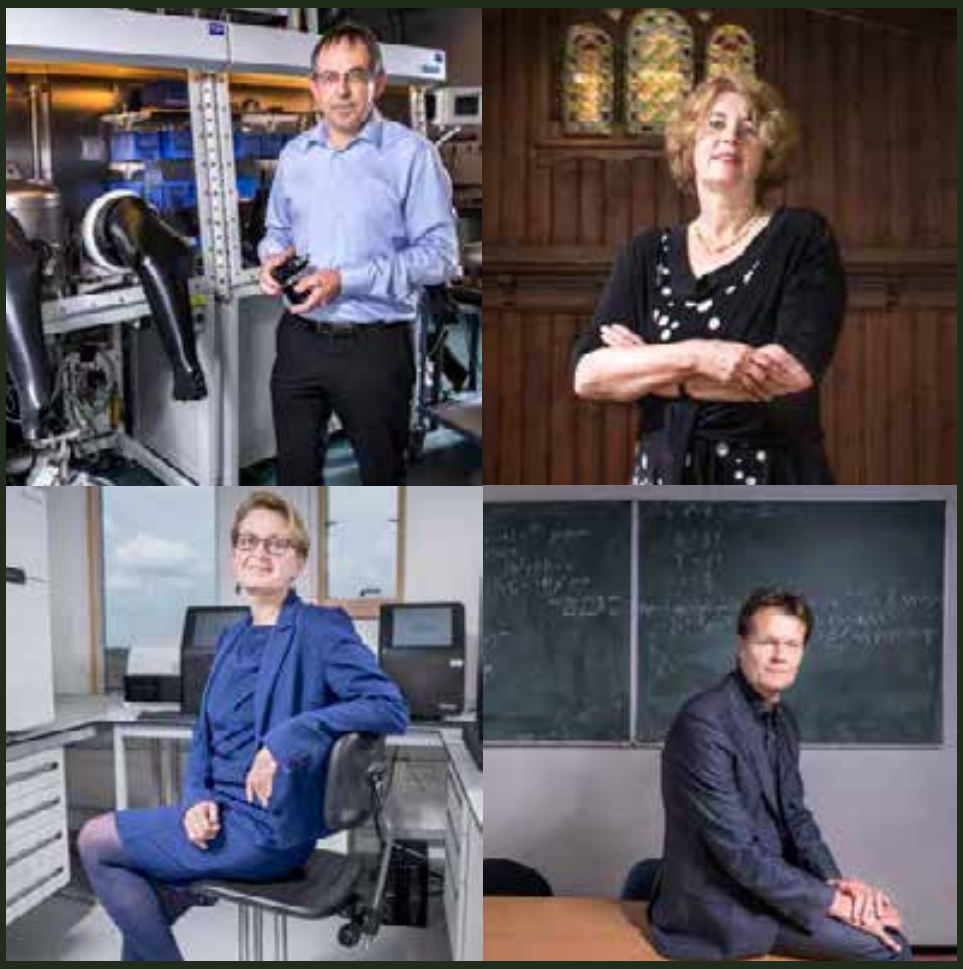
Science in focus? NWO on YouTube!

Meet the scientists that may change the world. Spinoz@night is an evening filled with science commemorating the NWO Spinoza Prize, hosted by Eva Jinek. Established scientists and young talent talk about their research and dreams for the future. Guests include 2015 NWO Spinoza laureates Cisca Wijmenga and René Janssen, who speak about DNA and solar cells.
Playlist: *NWO Spinoza Prize and Spinoza laureates*

How can we improve the way we restore and conserve art objects? The new research centre NICAS (Netherlands Institute for Conservation, Art and Science) brings together science and art. The scientists in question will discuss the NICAS research projects that aim to better preserve cultural heritage.
Playlist: *NWO Chemical & Physical Sciences*

NWO works with Dutch public service broadcaster NTR on a major national research project called 'Sprekend Nederland' to scientifically document samples of Dutch accents. This will occur via a special app, a Dutch web series called Spreekhokken and a TV programme called 'Bent spreekt Nederland'.
Playlist: *NWO Humanities*

youtube.com/NWOVenC



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