EXPERIMENTNL

SCIENCE IN THE NETHERLANDS

Ripples in spacetime

What can we do with gravitational waves?

The sex lives of adolescents

In search of the oldest teeth

Life after a breast amputation

Cutting down on waiting time

NWO

Netherlands Organisation for Scientific Research








SCIENCE IN THE NETHERLANDS

A world of difference

It's amazing how much difference a year can make! First of all in science of course. Think about it. Who would have thought a year ago that we could directly observe gravitational waves? Einstein predicted their existence a long time ago, but he presumed we would never be able to actually observe them. This event has opened up an entire new field of astronomy. It's a hugely important development and you can read about it in this magazine on page 54.

Dutch researchers have achieved novel results in other areas as well this year. I would like to draw your attention to the wonderful visual narrative about the evolutionary origins of jaws on page 50. Or the story about researchers working on an 'intelligent railway' with ProRail on page 44. There's much more, all of it equally alluring.

For me personally much has happened as well this year. A year ago I was still full professor in biophysics at Radboud University Nijmegen. And now I am introducing myself to you as the new chair of the Netherlands Organisation for Scientific Research (NWO). This new job will enable me to have a hand in shaping Dutch science in the coming five years. NWO does this primarily by funding researchers (on behalf of the Dutch government) so they can continue their fascinating and important work. This brings a great responsibility and honour, and also the privilege of being close to everything that is happening in the world of Dutch science. And it goes without saying that I want to share this world with you. That's why I'm pleased to have the opportunity, being the newly appointed chair, to present to you for the first time *Experiment NL*, the annual Dutch science magazine that NWO produces with *Quest*.

Stan Gielen
President NWO

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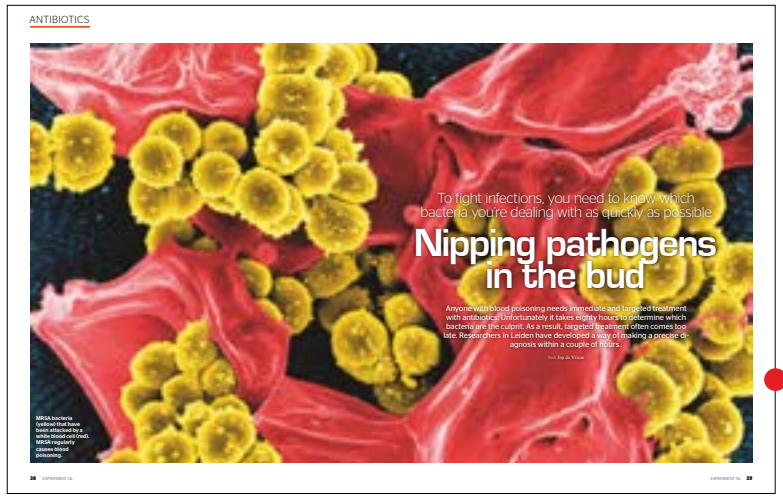

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High-flyers
What do these scientific top talents hope to discover?

Laureates

How did this year's NWO Spinoza laureates get where they are, and what does the future hold?

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BEHAVIOUR

Why smokers' brains crave nicotine so strongly

Addicted to memories

Quitting smoking or drugs often works for a short time, but not permanently. Many people give in sooner or later. Memories play a major role when people relapse into addictive behaviour. Can we erase them or adapt them?

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LOGISTICS

Waiting for a train in the name of science

Tuning in to the tracks

It's busy on the Dutch railway. Maintenance and repairs cause delays, which rail passengers are constantly bemoaning. That's why scientists are studying faster ways of fixing railway disruptions. Anthonie Boogaard's measurement equipment hears' defects in the tracks. *Experiment NL* tuned in with him.

ALSO EXPERIMENT NL

About NWO

The Netherlands Organisation for Scientific Research (NWO) is one of the largest science funding bodies in the Netherlands. With a budget of 800 million euros per year, NWO invests in more than 6,000 research projects every year at universities and knowledge institutes. NWO runs eight national research institutes, invests in large-scale research facilities and promotes the use of research results. The NWO divisions jointly promote strong ties between those working in the world of science and between science, society and industry.
NWO's organisational structure is going to change as of 1 January 2017. Read more about it at www.nwo.nl

NIOZ
NIOZ Royal Netherlands Institute for Sea Research

AMOLF
FOM institute AMOLF

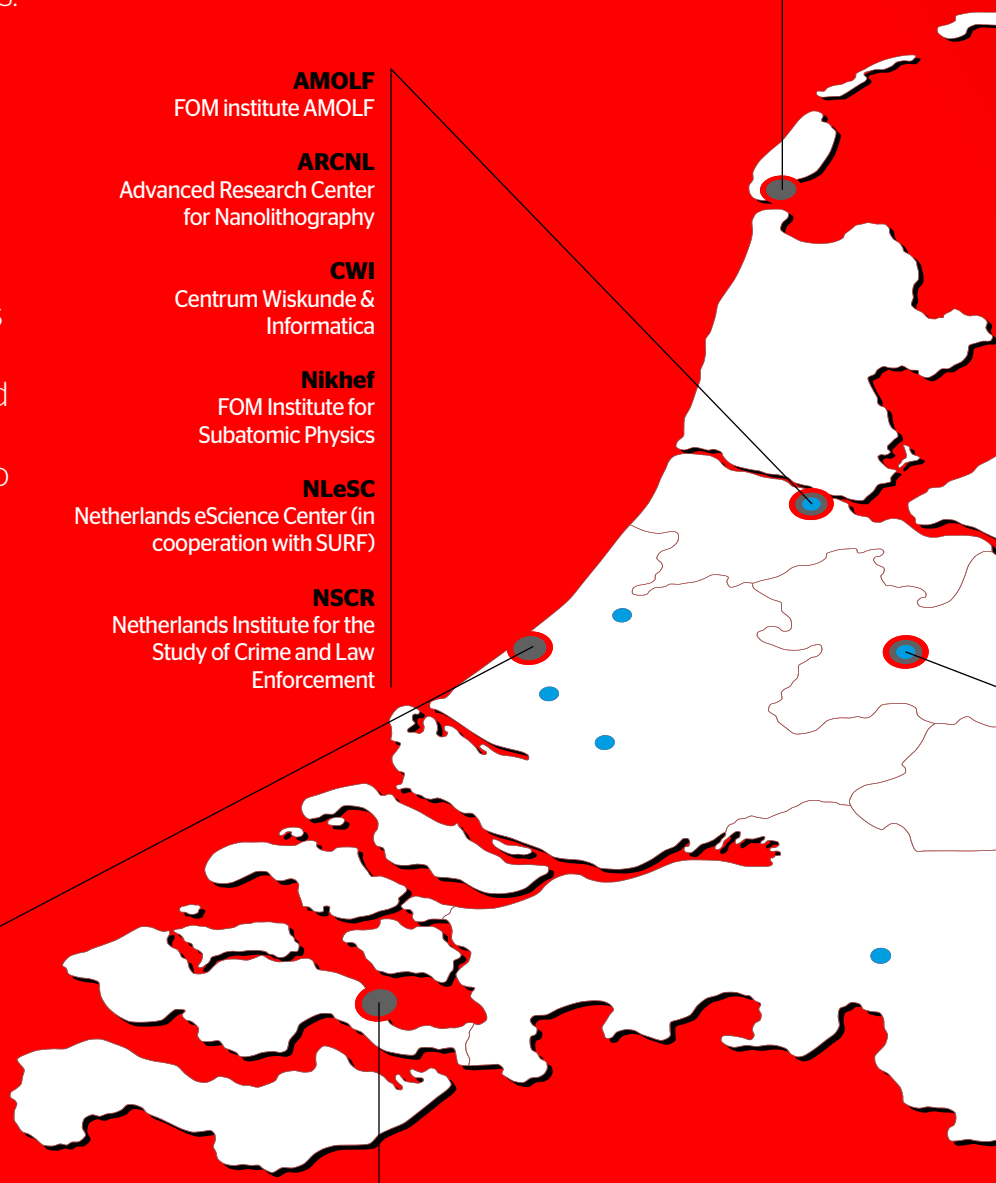
ARCNL
Advanced Research Center for Nanolithography

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
Chemical Sciences
Physical Sciences
Humanities
Social Sciences
Medical Sciences (accommodated at **ZonMw** – the Netherlands Organisation for Health Research and Development)
Physics (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)

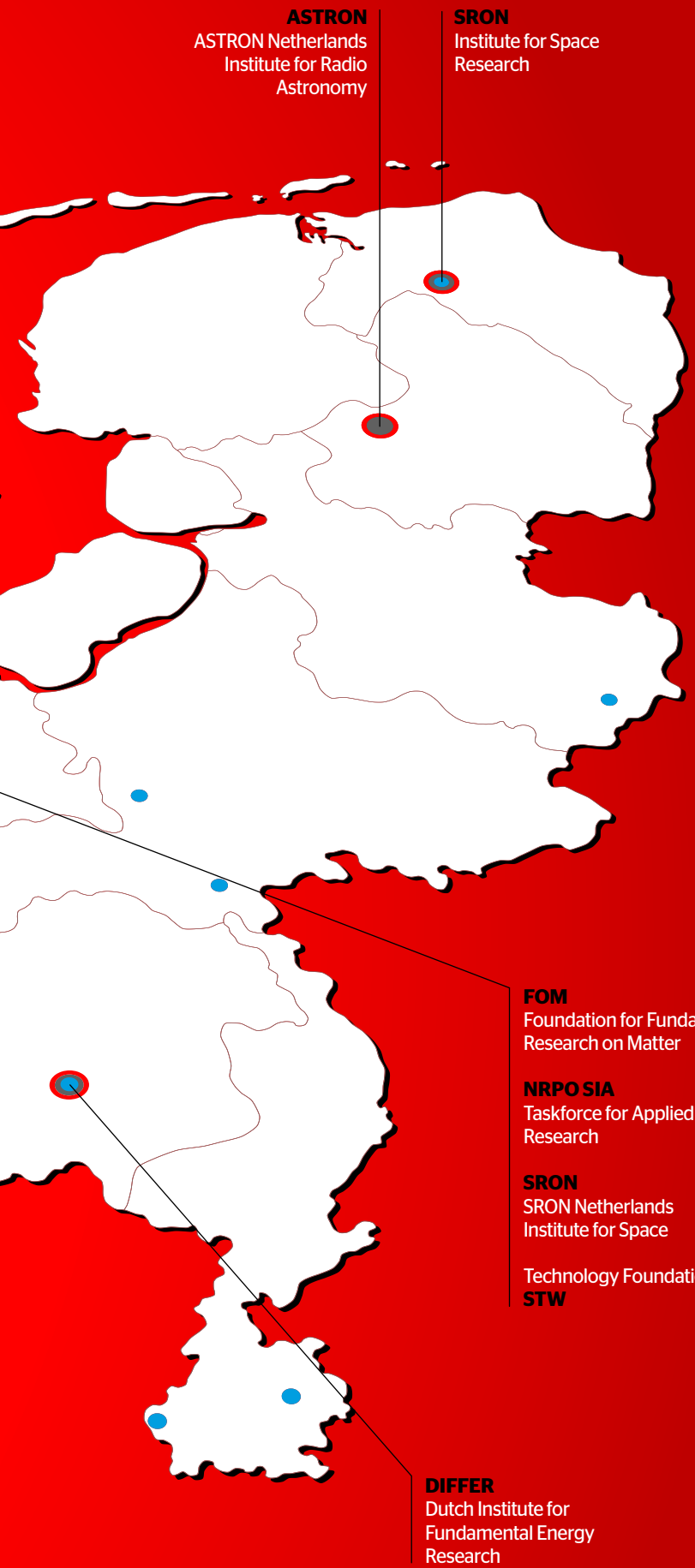
NIHC
National Initiative Brain & Cognition

NRO
Netherlands Institute for Education Research

NIOZ
NIOZ Royal Netherlands Institute for Sea Research

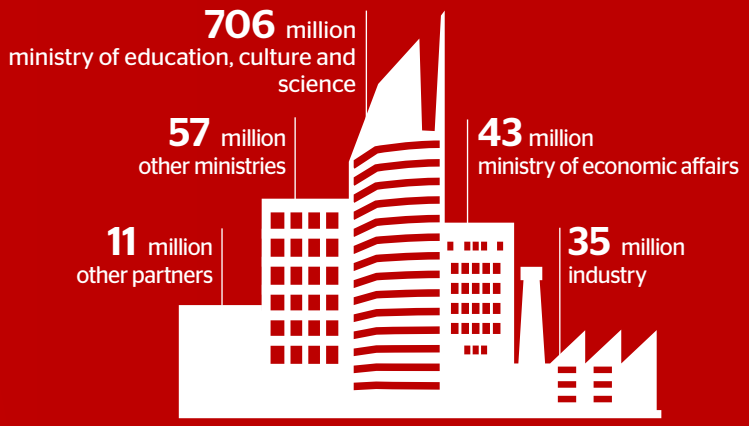
Universities

NWO divisions



2015 NWO BUDGET: €852 MILLION

Where do the funds come from?



NWO RESEARCH IN 2015:

6,073 research projects ongoing or completed

18,796 publications

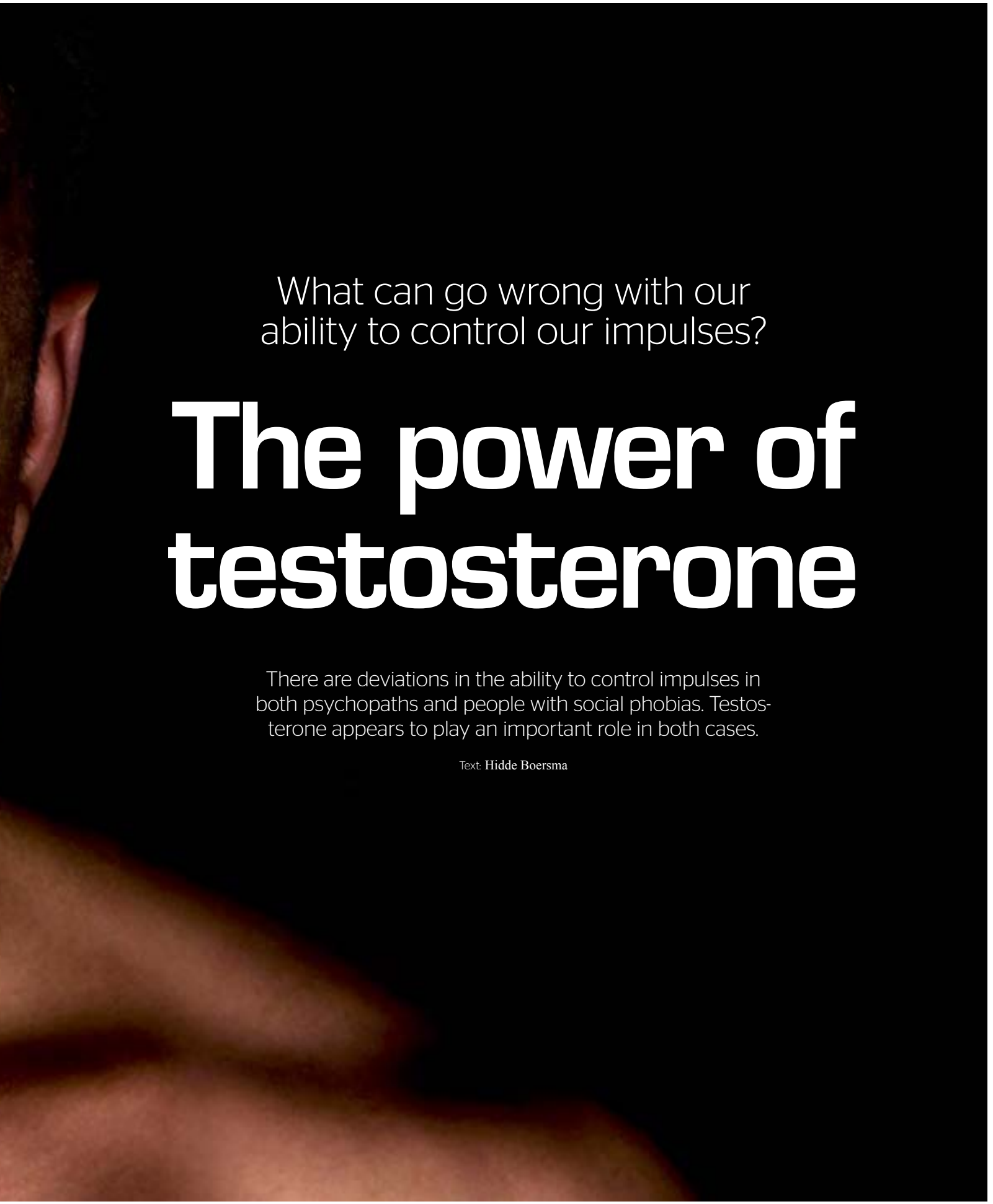
Research proposals given funding in 2015:

1,392 (out of 5,553 submitted requests)

Curiosity-driven research and talent programmes (e.g. Veni, Vidi and Vici): **643x**

Research on specific themes, such as cybersecurity or the climate, and research on the use of research results outside science: **552x**

Research infrastructure, such as databases and telescopes: **197x**



What can go wrong with our ability to control our impulses?

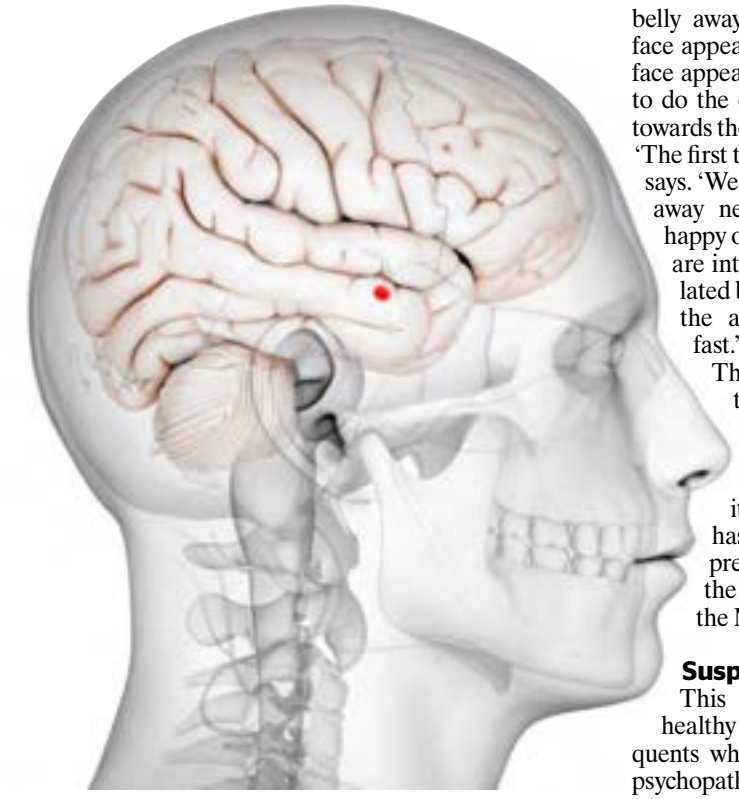
The power of testosterone

There are deviations in the ability to control impulses in both psychopaths and people with social phobias. Testosterone appears to play an important role in both cases.

Text: Hidde Boersma

Our cerebral cortex makes sure that we can control ourselves

The volunteer is dropped off at the front door of Radboud University's Donders Institute in Nijmegen in a police van. As the man is moved into the brain scanner, policemen stand guard on either side of the door. 'I feel completely safe,' says Karin Roelofs, professor of experimental psychopathology at the institute. Roelofs works in an unusual research environment, because she works with psychopaths. She tries to find out how a lack of control over impulses causes psychopaths to act the way they do. 'Our social behaviour essentially stems from automatic responses,' Roelofs explains. When we find ourselves in an unfamiliar situation, we have three basic responses: go for it (fight), get out of there (flight) or slam on the brakes (freeze). These responses are regulated by the amygdala, an almond-shaped area of the brain located deep in the temporal lobe. But people wouldn't be people if they didn't have their gut reactions largely under control. No one's 'go for it' impulse makes them run into a restaurant kitchen just because there's a tasty morsel in there: our brain ensures that we control ourselves.



The amygdala is found in the area around the red dot, deep in the brain.

New area responsible for control

We can thank this impulse control to our cerebral cortex, the outer part of our brain. In terms of evolution this is the newest area of the brain. Zooming in a bit closer, it's the front part of the cortex, the prefrontal cortex, that protects us from recklessly following our primal instincts. The prefrontal cortex is connected to the amygdala and can inhibit its signals, thereby preventing the amygdala from performing its intended actions.

Roelofs wanted to know whether this process could be disrupted in psychopaths. 'The classic notion is that psychopaths are very adept at performing tasks without emotion, but that's only part of the story,' she says. 'Psychopaths also have great difficulty controlling their emotions. They can impulsively carry out an action, without feeling any remorse. That's the reason why some end up in prison' (see also box on page 13: 'Assertive and full of self-confidence').

Counter-intuitive action equals slower response

To examine the impulse control Roelofs designed a simple but effective test. She showed test subjects happy and angry faces in an MRI brain scanner and asked them first to push the joystick on their belly away from them when an angry face appeared and pull it when a happy face appeared. In the next test they had to do the opposite: angry meant pull it towards them, happy meant push it away. 'The first test feels very natural,' Roelofs says. 'We are naturally inclined to push away negative people and embrace happy ones. The responses in this test are intuitive and are therefore regulated by deep cerebral nuclei such as the amygdala. They're extremely fast.'

The second test feels counter-intuitive, and that showed: the volunteers needed more time to respond. 'We see it happening in the brain: because it's counter-intuitive, the brain has to "think" and call on the prefrontal cortex to go against the intuition. That lights up on the MRI.'

Suspicion confirmed

This is exactly what happens in healthy people, but what about delinquents who have been diagnosed with psychopathy? It's not easy to get them under a scanner. Thanks to cooperation with the Pompe Foundation, an involuntary commitment institution where psychopaths are incarcerated, and following deliberations with the Ministry of Justice, Roelofs' research group got the go-ahead. If the psychopaths cooperated voluntarily, then they could be subjected to the brain scan and the joystick test under very strict police supervision.

Roelofs' gut feeling turned out to be right. Psychopaths do indeed have less control over their impulsiveness: their prefrontal cortex lit up less. There were two reasons for this. First, there simply was less activity in the prefrontal cortex, as a result of which there was less inhibition. The connection between the anterior prefrontal cortex and amygdala in psychopaths is less active when they have to control their emotional actions. Together, that can result in impulsive people who, in combination with their lack of empathy and remorse, can get into trouble quickly.

◀ One of the three basic responses in unfamiliar situations: flight. Get out of there, even if you're the king.

▼ Police officers are trained to shoot suspects in the foot or arm. Sometimes that goes wrong.

'Freeze' affects sight

Why do police officers often shoot suspects in the chest, instead of the feet or arms? We don't know exactly why, but one important factor could be that people under threat often 'freeze' – at which point they perceive rough features better than details, according to research by Karin Roelofs and her colleagues at the Donders Institute. Test subjects first learned to associate a red dot with an electric shock, which they saw right afterwards. The red dot thus initiated a so-called freeze response, in which the heart rate drops and we move less. During the freeze phase the test subjects had to indicate whether two pictures with a pattern were turned to the left or to the right. One picture had few details, the other many. It turned out that during the freeze volunteers found it easier to perceive the orientation of the first picture and had more difficulty with the second. So it appears that at such moments we are less sensitive when it comes to perceiving details, whereas larger forms are easier to discern. Roelofs is investigating whether this has an impact on officers who use their firearms.

Impulsivity hormone

Roelofs also wanted to find out why there's a difference between psychopaths: the inhibition of the amygdala by the prefrontal cortex was not equally weak in all psychopaths. The solution to the puzzle lay in the saliva samples that Roelofs and her colleagues had taken from each volunteer prior to the test. The concentration of testosterone can be measured in saliva. And as it turned out, the volunteers with a high concentration of testosterone in their bodies were the most impulsive. The hormone appears to modulate the activity of the prefrontal cortex, though it is still not clear how.

Does this mean that a high testosterone level automatically leads to more impulsive behaviour and always turns people into psychopaths? 'No', Roelofs says. 'On average, psychopaths have slightly higher testosterone levels than healthy people, but testosterone isn't what makes someone a psychopath. The affliction is much more complicated than that. There are ▷

Psychopaths have more testosterone, while people with a social fear have less

▷ several processes at work that slowly transform someone's brain into a psychopathic brain and which probably start at a young age.'

That also means that it's not certain whether therapies that are designed to block testosterone will necessarily help psychopaths to function better. 'We hope to find out more about that in future experiments,' Roelofs says. These experiments could potentially support current therapies as well. It certainly won't become a universally applied therapy though, because there are also psychopaths who don't have higher testosterone levels.

Testosterone affects fear

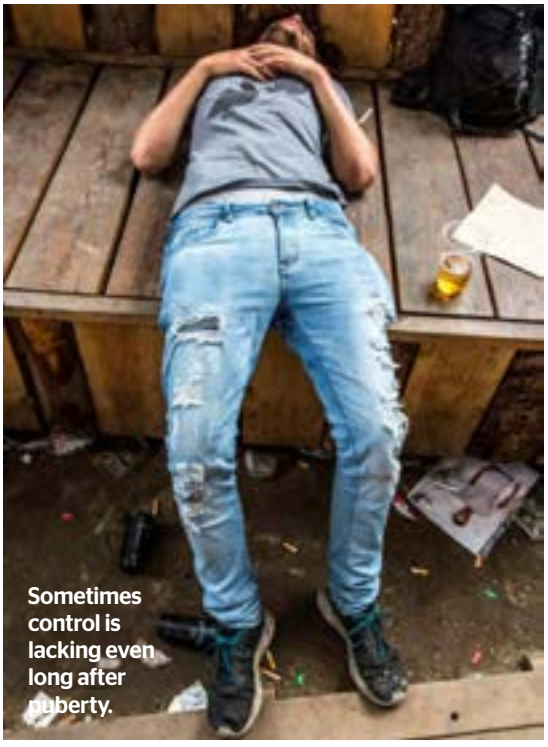
The knowledge that this hormone plays a role in regulating impulses previously led Roelofs to examine the opposite of psychopaths: people with a social fear who find it difficult engage in conversations or mix in a group. The possibility of using testosterone as an add-on to boost the efficacy of psychological interventions for these people is now under consideration.

Patients with a social anxiety disorder turn out to have a lower testosterone level than their healthier counterparts. The effect of that can be seen when they take the joystick test. For them, the abnormal act of pulling an angry face towards them is difficult to perform. That's evident because it takes more time for them to perform the action. In real life this is reflected in the fact that these people avoid social situations, which makes it difficult for them to lead a life with a family, friends and work.

Perhaps a shot of testosterone could soften the negative connection between the cortex and the amygdala to loosen these people up a bit. Roelofs designed an experiment with her colleagues with nineteen people afflicted by a social disorder and a control group with an equal number of test subjects. They were adminis-

How control develops

It's the time of secondary school and falling in love for the first time, but also a time of irresponsible risks and decisions. During puberty our impulses still have the upper hand over reason, until the brain is developed in such a way during adolescence that you can't make stupid decisions that easily anymore. Roelofs tried to identify this process by putting fourteen-year-olds who were in different stages of puberty under a scanner. The higher testosterone level and therefore the deeper into puberty a test subject was, the more likely it was for emotional control to be moved away from the deep part of the brain to the forebrain. The forebrain is essential for us to respond in a controlled way to really challenging situations. Roelofs wants to study which factors play a part in this. 'It could be that a predisposition to aggression, fear or other psychological problems is due to new control connections not having been properly established.'



Sometimes control is lacking even long after puberty.

tered something on two different days, either the hormone or a placebo, without knowing what they were being given on what day.

Shot of confidence

To test the effect, Roelofs had participants look at faces with a different expression on a computer screen. A typical characteristic of people with a social anxiety disorder is that they're less apt to look at other people in the eye and therefore turn their gaze away when confronted with a face. That can be monitored with eye tracking. The result? People with social anxiety looked away less frequently on days that they had been given testosterone. So a small dose of testosterone appears to be able to temporarily reduce social avoidance behaviour. Roelofs also discovered that patients were able to pull angry faces towards them more quickly in the joystick task if they had been given testosterone.

A daily shot of the male hormone in these patients' bodies is unlikely to be the future. 'The concentration of testosterone that we administered to participants was very low. You don't really notice it physically, but still you'd rather not put healthy people on medicine their whole lives,' Roelofs says. She is more in favour of a temporary dosage in combination with the usual exposure therapy. In that treatment, therapists have people with a social phobia slowly get used to social situations. This therapy will probably work more quickly with testosterone. □

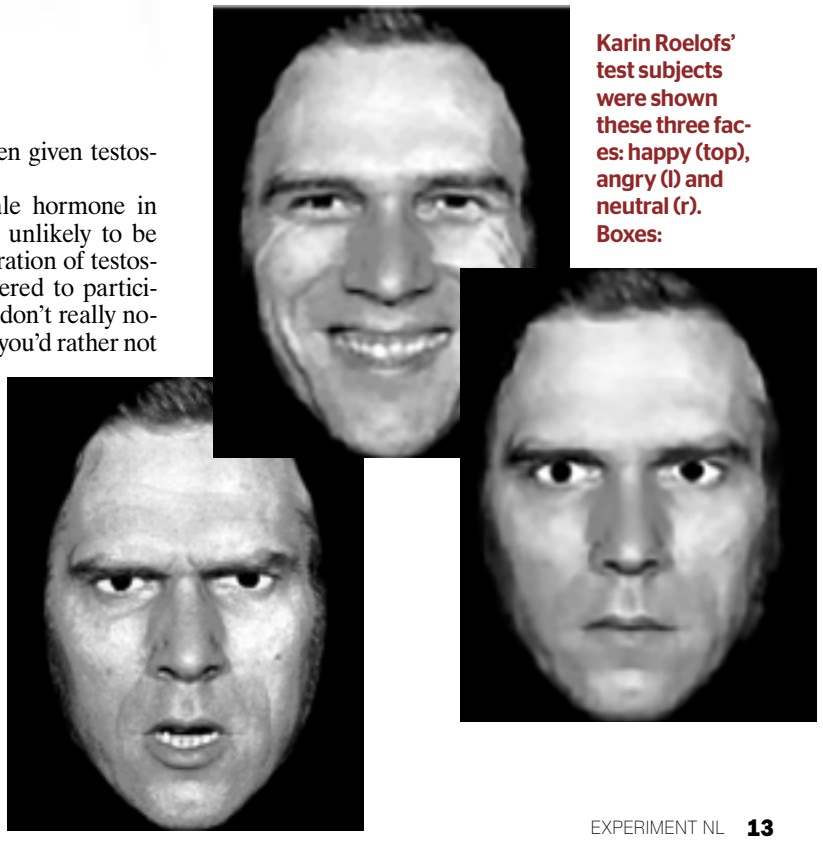
Assertive and full of self-confidence

Psychopaths have three typical characteristics:

1. Uninhibited: psychopaths have difficulty controlling themselves. They don't look far ahead and often act without a plan. They live for instant gratification and are not highly sensitive to social norms. Their behaviour is frequently destructive.

2. Mean: psychopaths have little empathy and rarely feel remorse. They look down on others, abuse them and dismiss authority. They use their meanness to gain power and control.

3. Guts: psychopaths are not very susceptible to stress. They can handle fear and the unknown well. They have considerable self-confidence and are assertive.



Karin Roelofs' test subjects were shown these three faces: happy (top), angry (l) and neutral (r). Boxes:

WILHELM HUCK, professor of physical organic chemistry at Radboud University.

A life's work

It doesn't seem more than a bag of molecules. Still, a cell can do something other bags of molecules can't: live. Where that difference comes from is the research area of Wilhelm Huck, professor of physical organic chemistry at Radboud University Nijmegen. In 2016 he received an NWO Spinoza Prize worth 2.5 million euros.

Text: Pepijn van der Gulden / Photography: Johannes Abeling

What is the aim of your research?
'We want to understand the chemistry of living cells. A cell is the basic unit of all life. We understand a great deal about its individual components and have a general idea of the processes that take place there, but we don't really understand how the cell works as a reactor. If I look at it from a chemist's perspective, it's just a bag of molecules. Nothing more and, I hesitate to say, nothing less. But what is it then? Why don't I get life when I throw together the right molecules? And then what's the difference between life and death? Because ultimately it is just a bag of molecules. George Whitesides, my postdoc supervisor, once said: "Chemistry is terribly boring, but it does give us life." Whatever you may think of chemistry, it is special that you can create something living with molecules.'

Is life nothing more than a bunch of chemical reactions?
'I think that's precisely what makes it fascinating. That you say, gosh, they're just chemical reactions, but we know them so well. Yes, but there are lots of them, and taken together all these chemical reactions do things that we actually could never have predicted. It's not like the Large Hadron Collider (the LHC, the large particle accelerator in Geneva, ed.) that does exactly what it should do. The big difference isn't about the number of parts. The LHC has many more parts than a cell. The big difference is that I have a design for one, but not for the other. If you go to IKEA and buy a bookcase, then you know exactly what to do. You simply follow the illustrations and when you're done you have a bookcase, or at least something that resembles one. The problem with a cell is that while I have all the parts, I don't know what goes where yet.'

At what point do you start to understand?
'"*Omnis cellula e cellula*", Rudolf Virchow once said (a nineteenth-century German biologist, ed.). In other words, all cells come from previous cells. But the first cell didn't come from a previous cell. We don't know exactly how life originated. That's why one of our questions is: how could it have originated? What conditions need to be in place for a chemical system to throw itself off balance, remain in that state, and then display functional behaviour that somehow grows, becomes more complex? Because that may have been what happened when chemical reactions in dead matter took place that eventually developed into life.
'An increasing number of research groups are finding that all the necessary components, such as lipids (fats, ed.) and sugars, were already there before there was life. But what happened to them? I have these same components as soon as I break up a cell. Except I'm unable to put them back together again in such a way that the cell is alive again. The more you understand how the system works, the more surprised you are that something like that was created.'

What distinguishes life from other chemical reactions?
'It's a self-regulating system that simply continues to function, even if something in its composition changes. If a river flows more powerfully, or other things flow into it, the system is always sufficiently robust to absorb everything that comes its way. A chemical reaction normally goes a step at a time in a single direction. If molecules collide, they immediately create the end product. Igniting gas in your cooker, which is irreversible, is an example. In living systems everything happens in small steps and in circles.
'You can see that clearly in a cell: all the steps in your metabolism are broken down into incredibly small steps, which keep repeating themselves. Take something like the gene expression that is continuously taking place in every cell. First you have transcription (the reading of the gene, ed.) and the translation (the building of a protein according to instructions that were just read from the gene, ed.). That means that it will take a while before you move from the one situation to the next. It's this de- ▷

‘I think that one day it will be possible to create a basic functioning cell’

Who is Wilhelm Huck?

1970: born on 1 January in Sittard.
1992: graduates cum laude in chemistry at Leiden University.
1997: obtains his doctorate at the University of Twente for synthesising miniscule chemical structures (metallodendrimers).
1997: goes to Harvard University in the US for postdoc research.
1999: teaches at the University of Cambridge in England.
2007: appointed professor of macromolecular chemistry at the University of Cambridge (England).
2009: awarded an ERC Advanced Grant for research on how the chemistry in a cell differs from the chemistry in a standard test tube.
2010: founds Sphere Fluidics in Cambridge, a company that supplies instruments for single cell characterisation.
2010: professor at Radboud University in Nijmegen. Decides to focus on the chemistry of living cells.
2011: receives an NWO Vici grant to construct artificial cells by placing cell components in microscopically small water droplets.
2012: appointed a member of the Royal Netherlands Academy of Arts and Sciences.

▷ lay that ensures that the whole system will display complex behaviour.’

How can you replicate such a system?
‘Bit by bit we’re trying to build a network of molecules that continuously influence each other. We’ve created one of these networks with the trypsin enzyme (which breaks down proteins in the small intestine, ed.). Trypsin can be created from the substance trypsinogen by cutting off a piece of its own tail. If you mix a bit of trypsin with trypsinogen, two trypsins will emerge, which together can produce even more trypsin, and so forth. It’s an auto-catalytic reaction, a reaction that accelerates with time. Conversely, there have been many drugs available for a long time that act as a trypsin inhibitor. If you add that kind of a drug to the reaction, then trypsin will cease to be made. We have created a molecule that will only become active when trypsin cuts a piece off, just as trypsin can activate itself by cutting the trypsinogen from its own tails. Trypsin thus seals its own fate by chopping off the tail of its own inhibitor. That means that we’ve created a negative feedback loop.
‘The more trypsin, the more of this trypsin inhibitor is made. So there are two processes: the one wants to constantly produce more trypsin, while the other continues to increasingly inhibit trypsin. If you keep adding trypsinogen and the inhibitor to the whole, you’ll get a reaction similar to what takes place in a cell: the concentrations of the substances go from high to low and from high to low again, etc. The processes chase each other around. If one value is high, then the other is low. It’s like a wave, similar to the rhythm of day and night.’

Is that the origin of life?
‘Has our trypsin network created something that’s kind of alive? Half alive, three quarters alive? So far it’s still a complex system that we can expand. For now, we are using two enzymes. There are about 30,000 in a cell, so we’re not suggesting that we’ll soon have constructed something that has the complexity of a living cell.
‘But at what point can you say that you have something living and at what point can you say that you have something non-living? You would think that this point exists somewhere, but don’t ask me where. And the fact that you don’t have a clue where that point may be, is slightly disconcerting, because it could be that this point doesn’t exist. Some people believe there’s no cut-off point, that there’s just a point where it links up perfectly. I don’t know. On the one hand you feel that life is really something more than non-living systems. But on the other hand you also ask yourself: but what is different? And that’s something I don’t know. So in my opinion you have no choice but to try to find out.’

How will the Spinoza Prize help in this search?
‘I actually have a project in mind, for which I hope to attract doctoral and postdoctoral students. I want to see whether it’s possible to discover how the chemical composition of a bacteria changes when it goes from being active to in ‘sleeping’ mode and vice versa. Think, for example, of cells that you can freeze or dry out, like yeast cells. If you put them in your closet at home, then they’ll do nothing. At that point, there’s no metabolism, no gene expression. So you’d be inclined to say that these cells are dead. But these cells are not dead at all, because as

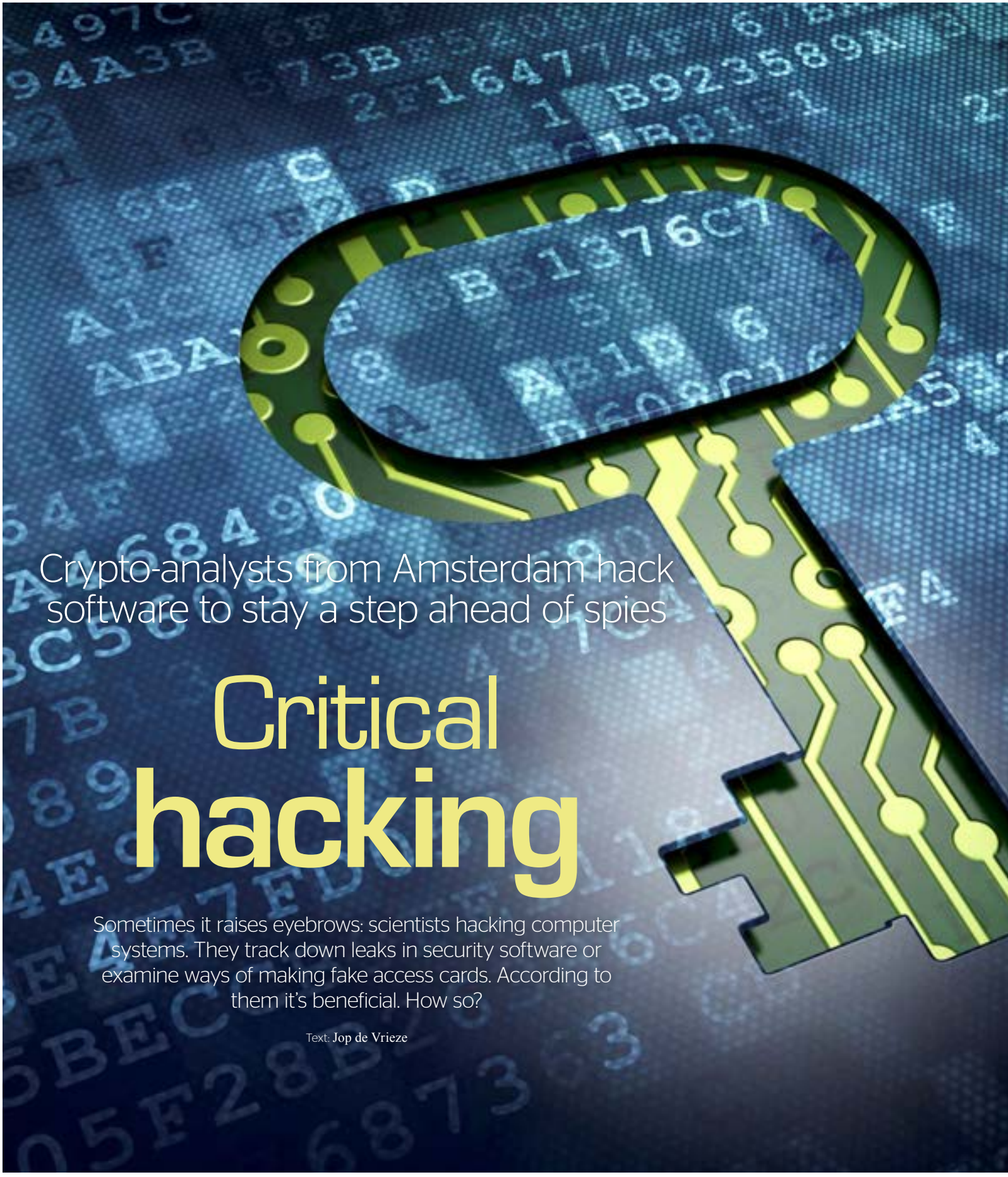
soon as you add water, presto! they start working again. We don't believe that this is anything special. But the cell has essentially gone from dead to living.

'I want to see how this critical transition at the molecular level will develop. Measuring it will be very tricky, but luckily the methods for these kinds of chemical analyses are rapidly improving. So it's quite probable that we'll be able to measure a substantial part of a cell's protein, preferably for individual cells. If we can determine the content of a large number of cells, in an active or dormant state, then we should be able to monitor how the chemical processes change during the transition. And then we want to look closely at the processes that shape the "motor" of the cell, such as energy-producing processes and maintaining the pH balance. I hope that we can identify a large enough number of processes to be able to form a picture of the cell, but a small enough number that we can model them on a computer. Once we know how a cell can emerge from apparent death to life again, then perhaps we can eventually create an inactive chemical system ourselves that will come to life as soon as we say "go"'.

How far will you go?

'I think that one day it will be possible to create a kind of basic functioning cell. It would have to be able to grow and divide. But to be honest I would be pretty happy if it were only able to grow. Could we use a cell that we manage to build ourselves one day? I doubt it, because if I wanted to build a cell, then I could build anything I wanted to with a cell that already exists with genetic manipulation. So why should I want to build an entire cell? If you get a much better understanding of how that cell really functions, then you'll get a much better understanding of how a drug works, for example. Then you can probably design drugs that don't necessarily target specific points in the cell, but attempt to address the entire system.

'I think we'll be busy with this research for the coming fifty years at least. It's painstaking work, but it's not necessarily a lost cause. I would rather work on something that's an enormous challenge and fail, than succeed in something that doesn't really amount to much. The big advantage is that every step we take is worthwhile, because you're working on something so incredibly difficult.' □



Crypto-analysts from Amsterdam hack software to stay a step ahead of spies

Critical hacking

Sometimes it raises eyebrows: scientists hacking computer systems. They track down leaks in security software or examine ways of making fake access cards. According to them it's beneficial. How so?

Text: Jop de Vrieze

A number of years ago Marc Stevens had a problem. The crypto-analyst from CWI (*Centrum Wiskunde & Informatica*), a mathematics and theoretical computer science research centre in Amsterdam, exposed vulnerabilities in security software in order to urge producers to improve it. But in May 2012 it appeared that Stevens' method had been used for espionage. Employees of the Russian antivirus company Kaspersky had made a remarkable discovery: thousands of computers in Iran and several neighbouring countries were infected by Flame, a virus that had been allegedly used to spy on Iran's nuclear programme. A month later, *The Washington Post* reported that the secret services of the US and Israel were behind this attack. Stevens was bewildered. These hackers' method was suspiciously similar to the way he had demonstrated, four years earlier, that the security of many websites was no longer effective. He had even made his software publicly available in 2009. Had he unwittingly played into the hackers' hands?

Password becomes hash

Not much later a security officer who had investigated the Flame attack called Stevens. Could Stevens show that the attack was not carried out with his software? He could. Using a mathematical method he showed that the hackers who spread the virus developed the software that they used themselves. It was probably happening before Stevens made his software public. The computers in Iran could be hacked because a specific part of the security, MD5, had been compromised. MD5 was used to protect websites for years. It is supplied by specialised companies to prevent, among other things, others from logging in to your account.

How? By making a kind of digital fingerprint of your password, for example, a so-called 'hash' that is made up of many numbers. This fingerprint cannot be put back in the original message (like your password), but it can be checked: the hash of your password is put next to the hash that the site made when you set your password. The chances of your coincidentally guessing the hash are miniscule. It already takes ages to go through all the potential combinations on a combination lock, and the same is true of a computer that tries out random hashes. MD5 uses 128-bit encryption with a sequence of ones and zeros. That means that there are two to the power of 128 possibilities, a 39-digit number. By comparison, a combination lock with three digits has 'only' ten to the power of three, yet thousands of possibilities.

Fake update

The art is to develop hash algorithms with so many possibilities that it becomes impossible to try them all out. That was originally the case with MD5, but because the processing power of computers has increased so dramatically, it is now possible to hack MD5 with a 'brute-force attack', Stevens say. That's not what he and his group do, however. 'We find even faster methods by developing smart mathematics. His team made the front pages around the world in 2008 by showing that MD5 could be hacked with this kind of math. In no time, MD5 was abandoned as website protection. But it was still used for more innocent purposes, for example to check whether an attachment has been downloaded correctly. And the virus in Iran showed that Microsoft had missed one application somewhere along the line, but it was an application that ended up affecting the security of Windows. 'The software developed by the secret services,' Stevens says, 'disguised itself as a real Windows update, because the software was secured with a false hash that seemed to originate from Microsoft.'

So it's not surprising that Microsoft contacted Stevens. The company may not be a friend of the Iranian regime, but it wants to offer secure software at all costs. Stevens' team developed software that can recognise fakes. This software is used for Internet Explorer, and is now even in Windows' source code, Stevens has been told. 'Yes, that's something I can put on my CV,' Steven says smiling.

Price of processing power down

By the time that MD5 had been scrapped almost everywhere, crypto-analyst Stevens and his colleagues had already ▷

How to tackle complex software

'It's crashing!' 'What's wrong now?' Familiar words. We use software for all kinds of things, but sometimes it can also make your work impossible and even unsafe. All the more reason to analyse programs: to learn what the expected behaviour of complex software is and why it behaves differently than you expect, argued professor Jurgen Vinju from *Centrum Wiskunde & Informatica* and TU Eindhoven in his inaugural lecture in 2016. It's similar to the analysis of a literary text, Vinju explains, because software is a language. Anyone analysing software does so much like a critic analysing a novel: from all kinds of perspectives. Just as a great plot can be ruined by poor syntax, brilliant software architecture can be wrecked by a small privacy leak. Software analysis is expensive and time-consuming. That's why Vinju is in favour of automation: smart programs can search quickly through large amounts of software data or compute what will happen if there's a change. It's already being done here and there, but for now we'll still have to heave a big sigh when our software refuses to do what we want.

Chips are getting faster and cheaper. What was secure a few years ago can now be hacked with a brute-force attack

The NSA Data Center in Bluffdale (US). Secret services like to nose around in just about everybody's secrets.

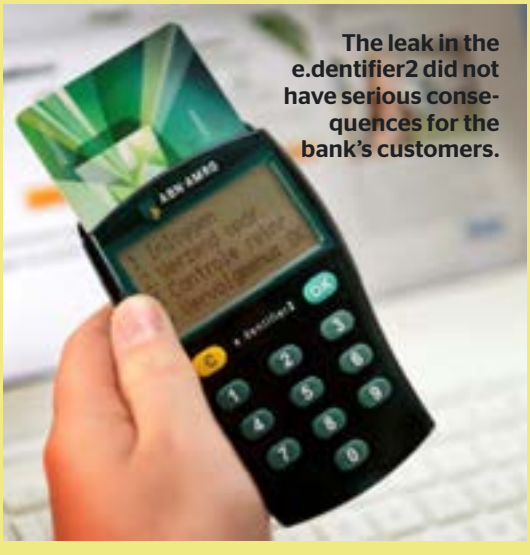
▷ shifted their focus to another security algorithm: SHA-1. That had also started to show cracks. The algorithm was developed by the National Security Agency (NSA) in the US in the 1990s. SHA-1 is more complex than MD5, so much more brutal processing power is needed to hack it. Someone had already proven that this could be done with smart math in 2005, but suppliers weren't worried yet: it would cost millions to buy the amount of computer chips needed to crack SHA-1. But the chips kept getting cheaper: in 2012 two Americans calculated that based on Stevens' work and the price of chips on Amazon.com it would now 'only' cost two million dollars. And they predicted that it would only cost seven hundred thousand in 2015.

And still industry was in no hurry. In 2015 they even wanted to postpone the transition to SHA-2, the newer software, by a year to 2017. At that point Stevens calculated that the cost of hacking SHA-1 had decreased to 100,000 dollars. In addition to mathematical improvements Stevens had also figured out a way of using graphics cards instead of regular computer chips to do the processing. These cards gave you more processing power for your dollar because they have a simpler construction than regular chips. They're a kind of processing powerhouse.

Hacking is no game

Within a few days, pretty much every producer of security software had switched to SHA-2. This software had been available for years, but it wasn't compatible with older computers. Stevens is satisfied with the decision. 'You shouldn't compromise everyone's security just to please some stragglers.'

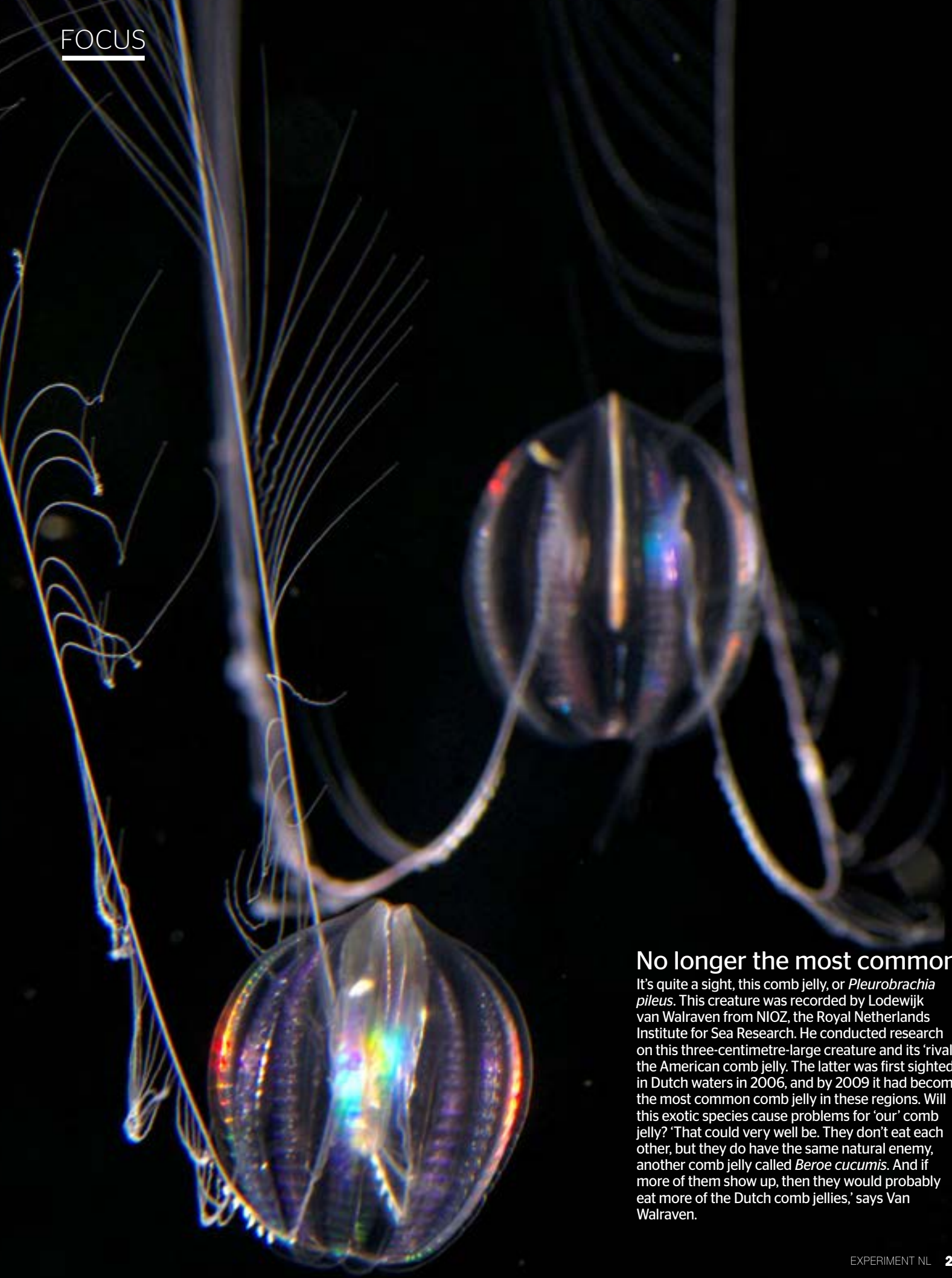
In the meantime, the researcher is searching for the next weak link. Sometimes it resembles a game when scientists test the security of government and company systems. But then Stevens is reminded of the phone call he received about MD5. 'It's serious business, especially in this age of increasingly powerful and scary governments,' he emphasises. 'Edward Snowden's disclosures (in 2013 he gave newspapers a large number of secret documents, ed.) show that NSA is really spying on everything and everybody and is using all their resources to do so. And of course the other superpowers aren't about to lag behind.' □



The leak in the e.dentifier2 did not have serious consequences for the bank's customers.

E.dentifier with a leak

It all started with computer science student Arjan Blom's graduation project to get to the bottom of the device that ABN AMRO customers use to do their online banking: the e.dentifier2. It ended with an unwelcome phone call to the bank, who were nevertheless grateful. The bad news was that the device had a security leak. People connecting it to their PC with a USB cable first have to enter their PIN number to carry out a transaction. Then the amount appears on the display of the e.dentifier2, which the user accepts by pressing the 'OK' button. It turns out that customers could also accept on their PCs. That may sound innocent, or even practical, says Joeri de Ruiter of Radboud University in Nijmegen, but if there's a virus on the computer then theoretically a completely different kind of transaction could take place, with a different amount and a different bank account on the receiving end. A few months after Blom's discovery a new version of the device was available. Without the leak: anyone connecting the new e.dentifier2 to their computer can only accept by pressing 'OK' on the device.



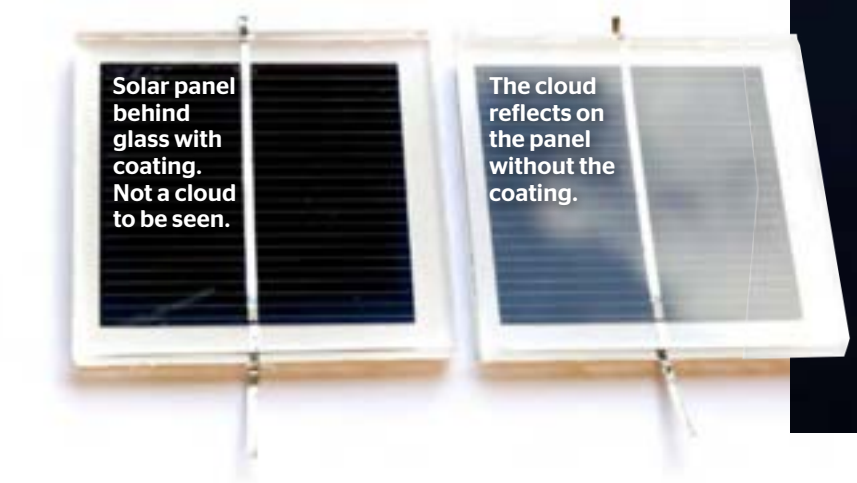
No longer the most common

It's quite a sight, this comb jelly, or *Pleurobrachia pileus*. This creature was recorded by Lodewijk van Walraven from NIOZ, the Royal Netherlands Institute for Sea Research. He conducted research on this three-centimetre-large creature and its 'rival', the American comb jelly. The latter was first sighted in Dutch waters in 2006, and by 2009 it had become the most common comb jelly in these regions. Will this exotic species cause problems for 'our' comb jelly? 'That could very well be. They don't eat each other, but they do have the same natural enemy, another comb jelly called *Beroe cucumis*. And if more of them show up, then they would probably eat more of the Dutch comb jellies,' says Van Walraven.

IN BRIEF

A coating against reflection

Shiny surfaces like glass reflect. That's annoying if you want to look outside at night, but it becomes expensive if it means your solar panels are losing efficiency. Under the supervision of Albert Polman, a research team from the NWO institute AMOLF has developed a coating against reflection. It consists of minute glass cylinders that refract light in a different way. The technology has proven to be effective: the tested solar panels were about 2.8 per cent more efficient, and the irritating reflection on smartphone screens diminished visibly. 'These experiments,' Polman says, 'are the proof of concept. The next step is to work together with producers of solar panels and screens to apply our newly patented technology.



Solar panel behind glass with coating. Not a cloud to be seen.

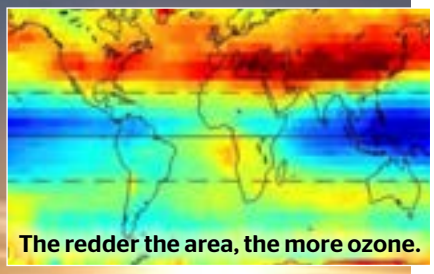
The cloud reflects on the panel without the coating.

Children are good witnesses in court

Contrary to what many of the crime scene investigations we see in TV series like CSI lead us to believe, judges largely base their verdicts on witness testimonies. Despite that important role, a bias exists about these testimonies that needs to be urgently revised according to Henry Otgaar from Maastricht University. 'The prevailing notion is that children are more susceptible to false memories and are therefore more unreliable than adults.' False memories are inaccurate memories created in retrospect by suggestions from outside sources. They're a danger to justice because they obscure the true picture. 'My research shows that adults are just as susceptible as children when it comes to creating false memories,' Otgaar says. 'Accumulated knowledge plays a particularly important role with adults, because it makes them fill in the blanks more quickly. Children don't have that problem.'

China 'exports' air pollution

The United States has done a great deal in recent years to reduce the emission of harmful gases, but the expected reduction of the greenhouse gas ozone failed to materialise. Willem Verstraeten investigated the cause of this at Wageningen University and KNMI: cross-border environmental problems. 'American measures are being partly wiped out by drifting ozone from China,' he says. Verstraeten examined satellite images and calculated the origin of the ozone in the atmosphere above the West Coast of America. 'Some of the ozone is produced locally, part of it is from higher strata of the atmosphere and part drifted over from China, where emissions of ozone levels between 2005 and 2010 have actually increased a lot.' According to Verstraeten it demonstrates the need to address air quality globally. 'In the Netherlands and Belgium about 25 per cent of the ozone originates from North America, but without their strict measures that percentage would be much higher.'

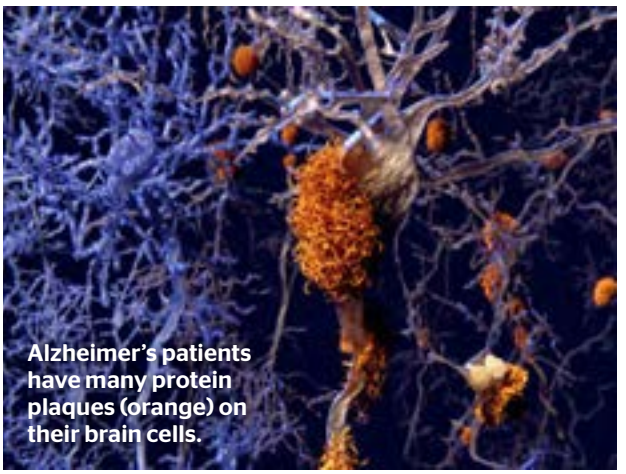


The redder the area, the more ozone.

The ceiling is just as packed with paintings as the walls.

Better memory for everyone?

Imagine: improving your memory and postponing Alzheimer's disease by swallowing a pill. That's the vision evoked by a flash of inspiration that Jos Prickaerts from Maastricht University had. 'I was working with a COPD drug that we call a PDE4-inhibitor,' he says, 'and I had a hunch, based on the structure of the molecule, that it could be effective in the brain too.' Initial tests with mice confirmed that idea: the animals' memories improved. 'We've now shown that it works in humans too. The medicine improved the memories of healthy, smart students as well as elderly people with and without an early stage of Alzheimer's disease.' Of course much research will be needed before Prickaerts' vision becomes reality, but it's a promising start.



Alzheimer's patients have many protein plaques (orange) on their brain cells.

Every detail of the Orange Hall online

The Orange Hall in the Huis ten Bosch palace in The Hague contains many unique artworks and decorations, which were commissioned by Amalia van Solms (1602-1675). She wanted to commemorate her husband, stadtholder Frederik Hendrik (1584-1647). Supervised by the architect Jacob van Campen, 39 painted panels and triumphal arches were created by 12 well-known artists at the time, such as Jacob Jordaens, Gerard van Honthorst and Salomon de Bray. Despite many other renovations in the Orange Hall over the years, these works made it through the centuries largely unscathed. When the hall was restored in the late twentieth century, a thorough investigation of the art was made. The result, which consisted of art historical reflections, but also materials research, has been compiled in an online catalogue. In 2015 King Willem-Alexander launched the comprehensive reference work, which is available to the public on the website oranjezaal.rkdmonographs.nl.

IN BRIEF

Statins inhibit cholesterol but also energy production for muscles, with painful consequences.

Muscle ache by statins clarified

At least a million people in the Netherlands with high cholesterol take statins, a medication that effectively combats that affliction. The only catch is that it causes severe muscle ache in a quarter of these people – reason enough for them to stop taking it. Frans Russel from Radboudumc investigated how statins can cause muscle ache, thereby taking the first step towards finding a solution. 'We discovered that statins exist in two merging forms in the body: a desirable, acidic form that lowers cholesterol, and an inactive lactone form.' It's the lactone form that causes the muscle aches. 'Our cells,' says Russel, 'contain mitochondria, cell organelles that produce energy for the cells. The lactone form blocks this process, which causes muscle ache similar to the kind we get after strenuous exercise.'

Development aid works

The Netherlands gives a lot of money to charity. Part of this development aid goes to co-financing projects, in which the Dutch government funds projects through local development organisations. But how effective is this aid? Jan Willem Gunning from VU University Amsterdam looked into the matter. Together with Jacques van der Gaag (UvA) he set up the biggest evaluation project ever on co-financing projects. 'We looked at projects in a medical way,' says Gun-

The minimum amount of exercise

Walking your dog every day is a good start to a long life.

What is the minimum amount of physical activity you need to perform to obtain measurable health benefits? That was the question behind a major literature study performed by Thijs Eijsvogels from Radboudumc. 'At least fifteen minutes of moderate intensity exercise per day, such as walking, decreases your chances of early death by thirteen per cent,' he concludes. '7.5 minutes of high intensity exercise, such as running or cycling, already decreases your chances of early death by thirty per cent.' Eijsvogels' findings come down to about half of the prevailing global exercise recommendations (150 min/week). Still, he wouldn't want to adjust it downwards. 'We really set the absolute minimum. More exercise is always better! The health benefits only start to level off after about six hours of very strenuous exercise per week.'

The population of the Afar region in Ethiopia has been living off of aid for almost two years due to drought.

ning. ‘You start with a basic situation, and the project is actually an intervention. The evaluation assessed how successful the intervention was.’ The evaluation generated all kinds of lessons, both for the project and the evaluation itself. Long-term partnerships work well, for example. ‘It wasn’t about awarding marks, but about learning from the process,’ Gunning emphasises. ‘But development cooperation is performing well.’

Old script revealed

Only twenty books remain from pre-Hispanic America. The Codex Añute is one of those rare treasures. ‘Or actually two,’ says Ludo Snijders, archaeologist at Leiden University. ‘The Codex is made of deerskin with a layer of gypsum, onto which the story is written. But a new technology, which can measure subtle colour differences, has revealed a story hidden beneath the outermost layer of gypsum.’ Both stories tell the history of a village from the Mixtec culture, in what is today southern Mexico. ‘The exciting thing is that while reconstructing it I didn’t come across any familiar elements. So it could be an entirely new story.’

The Codex Añute describes the origin of the village Añute, now called Magdalena Jaltepec.

Violence among Reformed youth during New Year’s Eve is greater in the countryside than in the city.

Religious violence

Dutch Reformed youth can be quite violent, and that can sometimes culminate in a minor riot on New Year’s Eve. Their faith dictates that God is the one who will judge them, and perhaps that explains why they’re not as likely to accept the authority of the police or the judiciary as other youth. Nonetheless, despite this conviction, their level of violence depends on where they live, argues Don Weenink from the University of Amsterdam. ‘In my research I discovered that Reformed youth in the countryside, in combination with alcohol consumption, are a little more violent than other groups. But those that live in the city, are considerably less violent.’ This could be attributable to changing group dynamics. ‘In the city,’ says Weenink, ‘perhaps these young people mix less with the nightlife, while in the countryside they create their own nightlife culture.’

How the Netherlands managed to monopolise an anti-malarial

The golden seed

In the nineteenth century the Netherlands used tree seeds from Peru to produce an anti-malarial medicine that the whole world wanted to have: quinine. Anthropologist René Gerrets is studying how the quinine monopoly came about and what impact it had on world history. 'Quinine was a kind of gold.'

Text: Dennis Rijnvis

Indonesians on Java around a heap of cinchona bark. Java was the largest producer of quinine between 1890 and 1940.

An Englishman and a native Peruvian are walking through the Peruvian rainforest. They stop every time they pass a tree with a reddish trunk. They hack out pieces of bark and taste the wood. It's 1863. The two men are looking for quinine, a substance with a bitter taste found in the bark of cinchona trees. When the native Peruvian discovers a tree with a strikingly bitter trunk, he climbs to the top to pick seeds. The Englishman looks nervously around, because if they're caught they'll get the death penalty.

That's more or less how it must have transpired: the search for cinchona seeds by the English businessman Charles Ledger and his local guide. Quinine was the only available medicine in the nineteenth century that could prevent and cure malaria. A drink was made from the bark of the cinchona tree that killed the malaria parasite. The government of Peru sold the tree's bark for a pretty penny, and the export of cinchona seeds was forbidden. Nevertheless, Ledger still managed to smuggle a considerable number of seeds to Europe. He sold some of them to the Netherlands.

Using the cinchona seeds, Dutch scientists did something no else had ever done before. They established plantations on the Dutch East Indian islands of Java and Sumatra, where cinchona trees grew with large quantities of quinine in the bark. And that's how the Netherlands became the only country in the world that could mass produce a medicine against malaria. 'It's an almost forgotten episode in our history,' says René Gerrets. The anthropologist from the University of Amsterdam discovered the Netherlands' quinine monopoly in old archives and is studying the impact that it had on world history.

The Zeeland fever

Until the twentieth century, malaria was a global plague, including in the Netherlands. 'Malaria mosquitoes couldn't survive our cold winters. But every summer they returned to the coastal areas and took their victims, especially in the province of Zeeland,' says Gerrets. No one knew what was causing the disease. People referred to malaria as 'the Zeeland fever'. Local inhabitants usually got a mild form, because they had built up a resistance against the parasite. But visitors from other provinces or countries often died from malaria. They weren't immune. 'The fevers of Zeeland have become the terror of neighbouring peoples,' according to the *Kroniek van Zeeland* in 1644. That was confirmed again later when British soldiers invaded Walcheren in 1809, hoping to drive Napoleon out of the Low Countries. Thousands of men fell prey to malaria on the island. The severely weakened army eventually decided to go back to England by boat. 'Malaria often played a key role on the battlefield,' says Gerrets. 'Countries that wanted to conquer unknown areas therefore pulled all the stops to find a way of fighting the disease.'

Gin and tonic against malaria

Many people still occasionally drink quinine: it's an ingredient in tonic. That's no coincidence. Tonic was originally a drink against malaria. It was mandatory for British soldiers and colonists in the nineteenth century in Africa and India to consume this quinine drink to protect themselves from malaria in these regions. They often mixed the tonic with gin, sugar and lime to supress the bitter taste of quinine. And thus the gin and tonic was born. The drink has an adventurous image. Soon people were drinking it in England too. The tonic available in supermarkets today still contains quinine, albeit less than in the past. If you're traveling to an area with malaria, you'd be better off taking malaria pills than having a gin and tonic though.

The Dutch withheld information about cultivating quinine from other countries

▷ Spanish explorers were the first to bring quinine to Europe from Peru in the sixteenth century. They saw indigenous people brewing a potion with it, which they used to cure patients with severe fevers. The Italian missionary Agostino Salumbrino had the idea in 1631 to use the 'cinchona tree potion' against malaria, because patients with this disease often had high fevers. He sent some cinchona bark to Rome from Peru when a malaria epidemic broke out there. He had struck gold. The patients got better, because the quinine in the potion killed the parasites in their blood.

Doctors all over Europe (including the Netherlands) subsequently began to treat patients with quinine. The demand for quinine shot up with the colonisation of Africa and Asia. European armies invaded one tropical area after another in the eighteenth and nineteenth centuries. Malaria was lurking everywhere. 'All of the soldiers that were sent to these areas needed to have quinine, but that wasn't possible,' according to Gerrets. 'There simply weren't enough cinchona trees in the rainforest.'

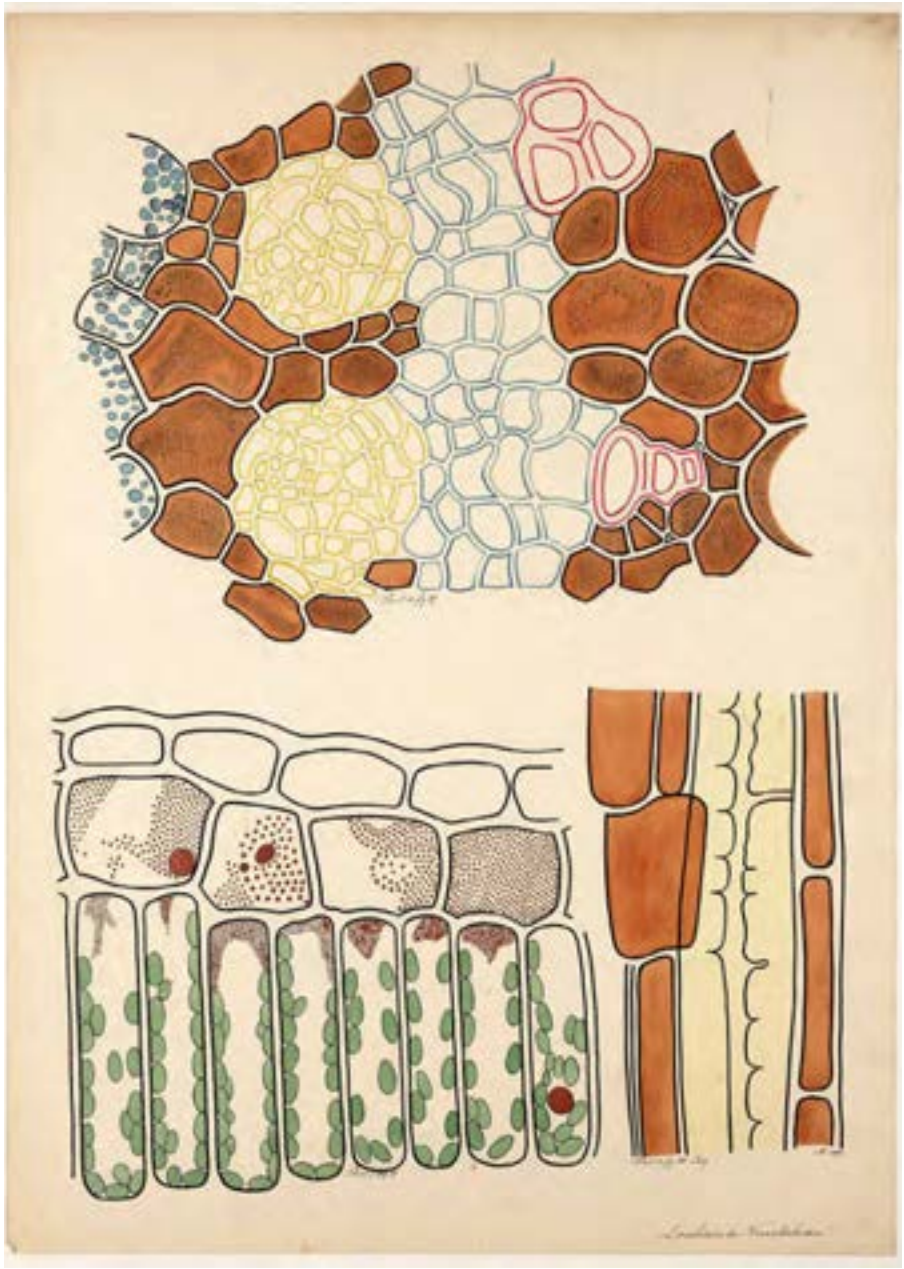
The only solution for the shortage of quinine was to grow the trees yourself. That's what prompted many countries to start doing business with smugglers of cinchona seeds in Peru. But using the seeds was not straightforward. 'Cinchona trees are picky. They only grow well on slopes, in fertile soil with good drainage, preferably in the shade and with lots of rain,' Gerrets explains. Indeed, cinchona plantations failed in most countries.

The bitter substance is found in the bark of the cinchona tree.

Cut and paste

It was no coincidence that the Dutch were successful on Java and Sumatra. The government put together a team of agricultural experts and plantation owners after purchasing the cinchona seeds from Charles Ledger. 'The partnership between scientists and entrepreneurs was unique in its time,' says Gerrets. It didn't take long to find the perfect place to build cinchona tree plantations: the volcanic slopes of Java. Cinchona trees, it turned out, grew better in volcanic soil than anywhere else. The research team also solved a growing problem. Cinchona trees with the highest volume of quinine in their bark often died, because their roots were highly susceptible to disease. The Dutch therefore started by planting strong cinchona trees with little quinine on their plantations. 'Then they cut down these trees so that only the roots remained in the soil,' Gerrets explains. Then the weak trees with large quantities of quinine were planted on top of the strong roots. That's called 'grafting'. 'The weak trees rich in quinine attached themselves to the strong roots, as a re-

From seed to cinchona plant. The plant is hard to keep alive.



A schoolbook illustration (1900) of cinchona cells with alkaloids, the active substances.

sult of which they grew better and got sick less often.'

The Netherlands plays games

This kind of knowledge about cinchona trees could have put a swift end to the scarcity of anti-malarial medicines. All the Dutch had to do was divulge to the rest of the world the secrets of their cinchona plantations. Every country would then be able to grow enough cinchona trees to protect their soldiers and populations from malaria. But the Netherlands didn't honour requests from abroad for help in cultivating cinchona trees. Sometimes seeds were sent to other countries, but they often died. Gerrets suspects that the Dutch deliberately withheld information. 'Foreign heads of state were fuming about the Dutch attitude. They must have often thought: those bloody Dutch say that they're cooperating, but they're not giving us the whole story.'

The export of quinine from the Dutch kingdom, meanwhile, took off. Ninety per cent of the world's supply was cultivated on Java and Sumatra. Plantation owners shipped about 7,000 tonnes of cinchona bark and 180 tonnes of pure quinine to other countries. The pivotal player in the sales network was the 'Kina Bureau' in Amsterdam, which was founded in 1913. At this bureau traders determined global prices for the anti-malarial with plantation owners. 'It was a price cartel,' according to Gerrets.

Monopoly collapses

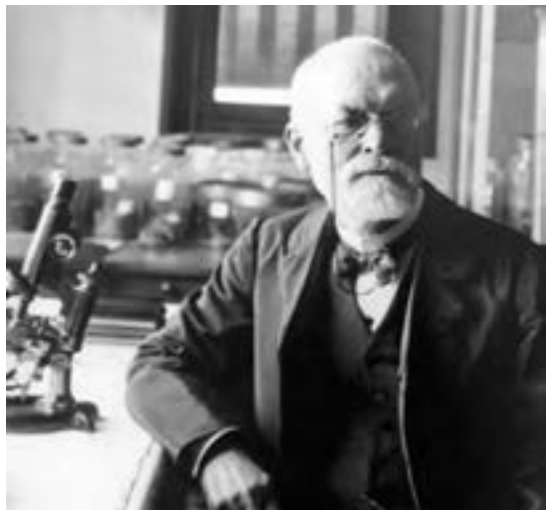
The Dutch quinine monopoly only ended during the Second World War. The Japanese invaded Dutch East India in 1942 and took command of the quinine plantations. Suddenly the Allies were cut off from their supply of anti-malarial medicine, which was indispensable for the American battle against the Japanese. 'Malaria was lurking everywhere in tropical Asia.' This accelerated the search for alternative anti-malarials. In the United States scientists brewed experimental medications in laboratories to fight the disease, such as atebrine. The pills containing this substance initially had many side effects. 'It gave you a rash and made you nauseous,' says Gerrets. But the American soldiers in Asia were forced to take atebrine. 'Anything's better than getting malaria.' The demand for quinine only abated after the Second World War. The reason for that was that the number of side effects of synthetic anti-malarials decreased over the years. And the pills became increasingly effective.

Today there's barely a trace of the cinchona plantations on Java anymore. Where the old plantations once stood, coffee and tea are now being cultivated. 'For the Dutch, quinine was a kind of gold hanging from trees,' Gerrets says. 'But now it's almost impossible to earn money from cinchona trees.' □

Do marshes make you sick?

The name malaria comes from the Latin *mala aria*, which literally means 'bad air'. For a long time, doctors believed that the malaria disease was spread by the foul odour hanging in the air above marshes. In 1880 the French physician Alphonse Laveran discovered that the infection is caused by a parasite often carried by mosquitoes in marshy areas. The Frenchman made his discovery after taking a blood sample from a patient that had just died. He saw tiny organisms moving in the blood. Laveran concluded that they were parasites causing malaria. His colleagues declared him mad. Doctors continued to attribute malaria to the air around marshes until the early twentieth century. It was only in 1907 that Laveran's theory was generally accepted, at which point he received the Nobel Prize for Medicine.

Alphonse Laveran made his groundbreaking discovery in Algiers, the city where he grew up.



High-flyers in the world of science

Moroccan law

Who? Nadia Sonneveld (40), researcher of Islamic law at Radboud University Nijmegen. **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 had originally planned to go to Egypt in 2013 to study family law, which is based on sharia there (the law of God, ed.). But after President Morsi was deposed that year, a negative travel advisory was issued. So I went to Morocco, where family law is also based on sharia. Legislative reforms were introduced there in 2004. Since then, women can request a divorce, for example, without their husband's permission or having to present evidence of serious grounds, such as abuse. I am examining how judges are dealing with these reforms in judicial practice. I have compiled court judgements and presented cases to more than sixty judges. I am focusing, for example, on whether judgements were influenced by the fact that a judge was male or female. It seems to make little difference. Except in a paternity case, in which male judges were quicker to grant a DNA test, even though they weren't legally obliged to.'

Who will benefit from this research?
'Knowledge about Moroccan legal practices are interesting for the Netherlands too, because they have an impact on the Moroccan community. If a Moroccan woman requests a divorce here, it is now immediately recognised in Morocco as well. That was much more difficult before the legislative reforms. It's interesting to see whether that is actually being applied in practice. I believe that it is.'

What inspired your research?
'In Morocco I was very inspired by the judges. They are looking closely at the question of how to put the interest of the child first. An important objective of theirs is to become more independent from the executive powers, especially the Ministry of Justice, so that the system becomes less corrupt.'

Nadia Sonneveld: 'Knowledge of Moroccan legal practices are interesting for the Netherlands too, because it has an impact on the Moroccan community.'

Wind in the city

Who? Gert-Jan Steeneveld (38), associate professor of meteorology and air quality at Wageningen University & Research. **Funding?** A Vidi grant worth up to 800,000 euros that enables experienced researchers to set up their own line of research.

What are you researching?
'I've been studying the urban climate since 2008. Temperatures on weather charts are often taken from weather stations in rural areas, though many people want to know what the weather's like in the city. We've ridden our freight bicycle equipped with a weather station through Amsterdam and Rotterdam during hot summer days. We used that data to create an extremely detailed weather model, so that you could see the heat in individual neighbourhoods.'

What are you going to do with the Vidi money?
'Temperature already gets a lot of attention, so now we want to look at wind. How is wind in the city and in rural areas interconnected? For example, in the countryside we see low-level jets in the evenings: thin atmospheric layers at a height of about one hundred metres with high wind speeds. They could be caused by cooling temperatures. Cities stay warm at night, so you wouldn't expect any jets there. And yet they have been measured. Do they blow into the city from the countryside? And what conditions do they need to survive in cities? We're also looking at how wind moves around in cities. Every city has high buildings where intense wind has knocked you off your feet. We want to continuously measure these gusts to see how strong they are and what kind of an impact buildings and street widths have on them.'

How will cities benefit from this research?
'City planning can benefit from knowing how wind behaves. Wind reduces heat, but it can also be dangerous and even have an economic impact. There are shops that have gone bankrupt because their street had an unpleasant wind climate. I also want to make a wind atlas for the use of wind energy. There are already small turbines that can be put on the roofs of houses. A wind atlas would show which neighbourhoods are suitable for capturing wind and how much energy it would yield.'

Gert-Jan Steeneveld: 'Wind reduces heat and can even have an economic impact. It's useful to know how wind behaves for city planning.'

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: Anouk Broersma / Photography: Johannes Abeling

Blurring memories

Who? Iris Engelhard (46), professor of clinical psychology at Utrecht University. **Funding?** A Veni, Vidi and recently 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 study factors involved in the development of post-traumatic stress disorder (PTSD). I also examine how emotional memories can become less aversive. For example, in Eye Movement Desensitisation and Reprocessing (EMDR), a patient thinks about a traumatic event while her or his eyes follow the horizontal movements of the therapist's finger. For a long time it was unclear how that worked. We discovered that a disturbing memory can also get blurred if people do mental arithmetic or play a computer game while thinking about it. So there's nothing special about eye movement, it's more about doing a demanding dual-task.'

What are your plans with the Vici grant?
'I will continue to build on my previous research but will focus more on other anxiety disorders. While PTSD revolves around flashbacks, other anxiety disorders are primarily about potential future threats. These can be experienced as vivid and intrusive images. An important question is whether these "flashforwards" can be weakened in the same way as flashbacks. And does it prevent relapse? Relapse is still a major problem in the treatment of anxiety disorders.'

What inspired you to choose this field?
'As a Fulbright scholar at Harvard I spoke to Vietnam veterans who had combat exposure. One of them said: "I'm not sure that I belong in this study. What I experienced is much less severe than what some of the others have experienced. I am happily married, have a good job." Later I heard that he had been shot down as a helicopter pilot and had been locked up in solitary confinement. It fascinated me that he mitigated his experience to that extent and recovered from it. That's when I thought: I want to do more research on this.'

Iris Engelhard: 'Our question is: can the flashforwards during anxiety attacks be weakened in the same as flashbacks with PTSD and does this enhance treatment effects?'

X-ray in space

Who? Elisa Costantini (42), senior researcher in astrophysics at SRON, the Netherlands Institute for Space Research.
Funding? A Vidi grant worth up to 800,000 euros that enables experienced researchers to set up their own line of research.

What does your research focus on?
'I study the chemistry of the interstellar medium. That's all the material that fills up the space between the stars in a solar system, clouds of gas and dust. When this material explodes, new planets and stars are born. If we figure out the composition of the interstellar medium, then we'll also improve our understanding of how planets are formed. I use observation satellites to view bright sources far away from Earth, such as neutron stars. These stars emit X-rays that illuminate the space material between the Earth and the source. I am examining how this interaction between the interstellar medium and X-rays works and which chemical substances, such as oxygen, iron or silicon, the interstellar medium consists of in specific places in space.'

Who will benefit from this research?
'Right now we're observing a lot of exoplanets, planets outside of our solar system. Often they're gas giants like Jupiter. Few rocky planets such as ours are being discovered. That's why many astronomers are asking themselves how a planet like Earth is born. What material is necessary for that? And what materials are present for this to happen in specific parts of the universe? These are questions that this project is hoping to answer.'

What do you believe is the most important discovery in your field in recent years?
'The study of the interstellar medium via X-rays is still fairly new. We simply didn't have the right instruments till about fifteen years ago. Our research group and a number of American groups were the first to show, in about 2000, that you can see the interstellar medium via X-rays and that you can obtain a great deal of data from it. That was a breakthrough, the birth of this field.'

Elisa Costantini: 'Our group was one of the first to show that you can see the interstellar medium via X-rays. That was the birth of a new field.'

When will there be as many women as men in science?

Fifty-fifty please

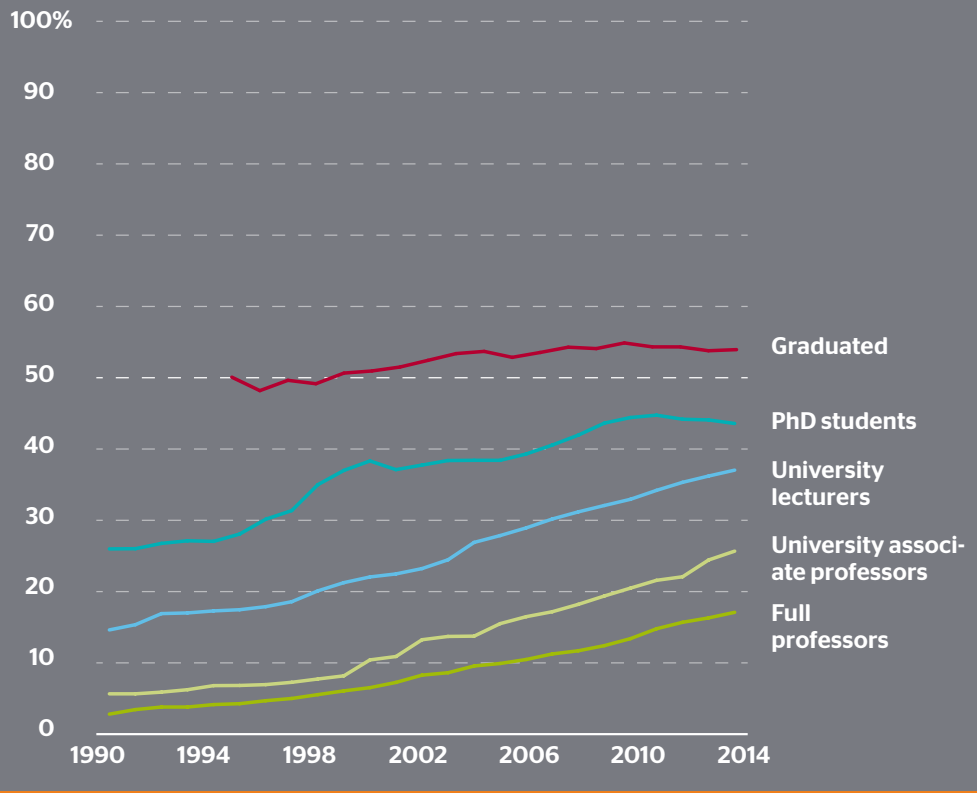
The number of men and women in the world is pretty much equal. But in the world of Dutch science that's far from the case. Most of the positions at universities are overwhelmingly held by men. Indeed, in the top echelons of science by late 2014, only 516 of the 3,065 professors were female. NWO's Women In Science Excel (WISE) programme aims to redress the balance.

The number of women in science still disappoints

First the good news: the ratio of men and women in science is improving. The Dutch Network of Women Professors, which has published the Monitor of Women Professors every three years since 2003, has seen the number of female university associate professors and full professors rise in recent years. The bad news, though, is how slowly this is unfolding. The most recent Monitor, from 2015, states that 'the share of women professors in Dutch science is only gradually increasing: at this rate, we'll have to wait until 2055 to see any kind of equal representation of men and women among professors.'

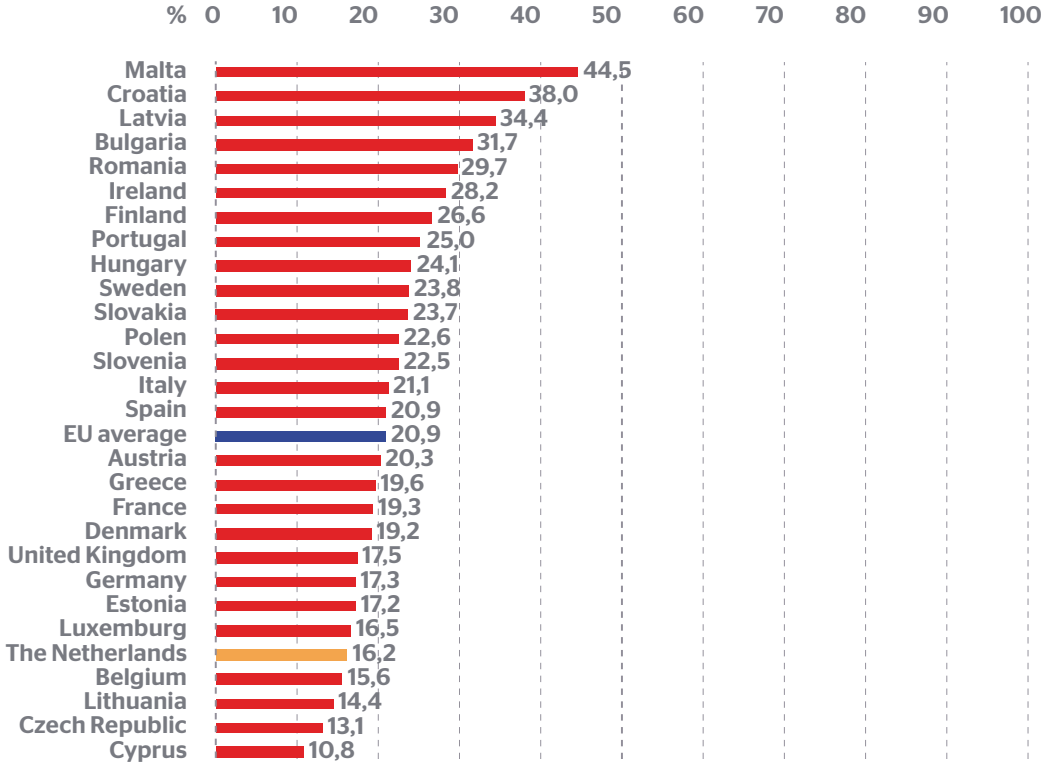
The cause is not a lack of female talent. On the contrary, in 2014 more women than men graduated from university (53.4% versus 46.6%). But that all gets turned upside down when it comes to the next step in these people's scientific careers (from PhD candidates to professorships), according to the Monitor. Figures from 2014 show that among PhD students only 43.5% of university FTEs were women. Among university lecturers that was 37%, among associate professors 25.6% and among full professors 17.1%.

Is that bad? In April 2016, Jet Bussemaker, minister of Education, Culture and Science, said that 'a diverse team is a condition for innovative, creative and groundbreaking research.' According to her, this diversity will increase if more women work in the world of science. To promote that idea, NWO launched the Women In Science Excel (WISE) programme. It aims to create twenty positions for young female scientists at NWO research institutes in the coming five years. They will conduct research for five years, after which they will be given the opportunity of securing a permanent position at the institute.



Bottom of the barrel

That the Netherlands is lagging behind when it comes to women in science is evident if you compare the percentage of female professors in other EU countries. The European Commission keeps tabs on the figures in the periodical She Figures. In 2010 the Netherlands was number 18 out of 22 countries that had submitted figures at the time. Three years later, when data became available from 28 countries, the Netherlands was number 24. Only Belgium, Lithuania, the Czech Republic and Cyprus had a lower percentage of female professors. With 44.5% of its professors female, leader of the pack Malta (which was still hovering around the bottom of the list in 2009) comes the closest to having a fifty-fifty balance.



Permission granted

Science for women in the Netherlands began in the late-nineteenth century. In Sappemeer, Aletta Jacobs (1854-1929) grew up in a doctor's family, where she listened to discussions as a girl between her father and brother, who was studying to become a doctor. 'That's what I wanted too,' Jacobs would later write in her memoires. Out of the question. At the time, universities were the exclusive domain of males. When she was seventeen, Jacobs therefore wrote a letter to Prime Minister Johan Thorbecke asking him to 'grant permission to attend academic lessons in Groningen.' Thorbecke consented. But attending lectures was something different than really studying. So Jacobs also asked if she could take exams. That too was authorised: King William III gave his personal consent. That turned out to be extremely important later when the 'Higher Education Act' was ratified, which made it possible for women to study from 1876 onwards.
When Jacobs took her exam in medicine in 1877, she was the first woman in the Netherlands to complete a scientific degree, and two years later she took her PhD. But that's not to suggest that women started studying en masse. Forty years later, in 1917, only a quarter of the students at Utrecht University were women. That was the year that the first female professor was appointed in the Netherlands, however: Johanna Westerdijk (1883-1961). As a phytopathologist (someone who studies plant diseases) she ran the Central Bureau of Fungal Cultures, where, considering the period, many women worked. But there was no policy for attracting women, says Westerdijk. Sure, the scientific world was run by men. But to change that women had to use their talent to perform tough and serious work and have the courage to put themselves more in the forefront. That's exactly what Westerdijk did, according to her biographer Patricia Faasse in *Een beetje opstandigheid* (A little defiance) (2012).


Aletta Jacobs, the Netherlands' first female academic.


Rianne Letschert, rector in Maastricht.

Youngest rector

She's not the first female rector in the Netherlands, but she is the youngest ever. Rianne Letschert (1976) was appointed to this position as of 1 September 2016 by Maastricht University. She studied international law at the University of Amsterdam, the Université de Montpellier (France) and Tilburg University, where she also defended her dissertation. In 2011 she was appointed professor of victimology and international law. Letschert received a Vidi grant from NWO in 2015 for her research on the impact of international tribunals on societies and people who have been the victims of serious violations of human rights and international crimes. This research will remain in Tilburg as she departs for Maastricht, but Letschert will continue to supervise it.

BART VAN WEES, professor of applied physics at the University of Groningen.

Working on the scale of a nanometre

Small atoms, majestic materials

Can a material be two-, one- or even zero-dimensional? Yes, according to Bart van Wees, professor of applied physics at the University of Groningen. Out of curiosity he is studying these new materials, which will undoubtedly be found in a huge variety of technological applications one day. In 2016 Van Wees received an NWO Spinoza Prize worth 2.5 million euros.

Text: Anouschka Bush / Photography: Johannes Abeling

You work with nanomaterials and nanodevices. What exactly does your research focus on?
'The focus of my Physics of Nanodevices group and that of the Zernike Institute for Advanced Materials (also part of the University of Groningen, ed.) is quantum engineering with advanced materials. We develop and study new materials and circuits that can eventually be used to make more efficient solar cells, for example, or better electronic equipment. In doing so, we make intelligent use of the laws of quantum mechanics, which apply at a small scale. An important guiding principle in my work is: how do you go from something that is macroscopic to something that I call "mesoscopic"? "Meso" means "middle", it's in between macroscopic and microscopic. Microscopic involves a scale of individual atoms and molecules. With macroscopic you're already talking about several millimetres. Mesoscopic means materials with very basic structures, materials that are two-, one- or even zero-dimensional.'

So two-dimensional materials exist?
'Definitely. Graphene is a good example. That was the first purely 2D material to be discovered. Konstantin Novoselov and Andre Geim won the Nobel Prize in Physics for it in 2010. It's a layer of graphite, pure carbon, just one atom thick with all kinds of interesting properties. It's one of the strongest materials that we know of. In addition, it's an extremely good conductor of electricity and heat, and it's highly resistant to heat.'

2D means that a material is only one atom thick?
'No, a material doesn't necessarily have to be one atom thick to be called 2D. The point is that it's so thin that the electrons in it can only move in two directions. We call a nanotube, a rolled up layer of graphene, 1D, because the primary motion of electrons is in one direction. We talk of 0D when electrons are completely confined and have nowhere to go. A carbon buckyball is a good example. The most well-known buckyball is just like a football with a pattern of pentagons and hexagons made of carbon atoms.'

Spintronics is one of your research focuses. It sounds like science fiction. What is it exactly?
'Spintronics is electronics that works with "spin". The most important property of electrons in traditional electronics is that they are charged. As a result, they can not only transport electricity, but also data, which is what happens in computers. But these same electrons can also transport a magnetic property: spin. They're similar to spinning tops that spin in a certain direction: to the left or to the right. As a result, they become something that resembles small magnetic compass needles. That was discovered ages ago, in 1925. But practically speaking not much was done with that knowledge until 1988, when Albert Fert and Peter Grünberg discovered the "GMR effect", or giant magnetoresistance. They won the 2007 Nobel Prize for that.'

How exactly is that related to electronics?
'The consequence of the GMR effect is that you can convert magnetic information into electrical information. And that's interesting because a great deal of information storage is magnetic, such as your computer hard disk. But the information is transported electronically. So you have to convert magnetic to electronic information and back again. That used to be a highly complicated process, which was tricky to miniaturise. But the discovery of the GMR effect made it much easier to read magnetic information. That was the birth of spintronics. And before long it was something found in every hard disk.'

Spintronics is a standard part of hard disks in computers. Why is the general public so unfamiliar with it?
'That's partly related to PR. We nanophysicists aren't as good at PR as for instance astronomers. Every new black hole that's ▷

‘We showed that you can transmit signals through an insulator’

Who is Bart van Wees?

1961: born on 4 August in Nootdorp.
1985: graduates from the Delft University of Technology in applied physics.
1989: obtains his PhD cum laude with his dissertation *Quantum ballistic and adiabatic transport, studied with quantum point contacts*. In it, Van Wees describes a striking phenomenon in the conduction of nanowires: when wires expand, then conduction does not increase proportionately but in quantised steps.
1989-1991: postdoc researcher at the Delft University of Technology.
1991-2000: senior researcher at the Thin Layer Physics Group, part of the Faculty of Mathematics and Natural Sciences at the University of Groningen. His primary focus: superconductivity and spintronics in semiconductors.
2000: appointed professor of applied physics, specifically the physics of nanodevices at the University of Groningen. Focuses on the emerging research area of spintronics in new materials.
2003-present: leader of the Zernike Nanolab project in Groningen.
2008-2010: *thrust leader* of organic electronics at the Zernike Institute for Advanced Materials, University of Groningen.
2010-present: *focus area leader* of nanostructured materials for electromagnetic functionality at the Zernike Institute for Advanced Materials, University of Groningen.
2013-present: coordinator of the spintronics Work Package in het EU Graphene Flagship project.

▷ discovered is announced with great fanfare. I think we’re a little too modest. And perhaps nanophysics has less of an appeal. It’s a very broad area and quite complex: usually it becomes interesting if you already know some physics.’

How did you end up in this field? What fascinated you about nanophysics?
‘I encountered it during my graduation project and my PhD work in professor Hans Mooij’s group at TU Delft. What fascinates me about this field is that by using fairly simple tools you can access atomic-level physics, where you can really do practical work with quantum mechanics. The fact that you can get something up and running that excites other people. The advantage of nanophysics is that the principle is very simple: 2D, 1D and 0D systems are elementary. You can describe the electrical properties of 2D graphene in a few pages, and the electrical properties of 1D and 0D semiconductor materials would even fit on a single page. And the link between technology and science is extremely straightforward. What you conceive is tangible: this should work like this and like that, which you can then test without having to make all kinds of complicated and expensive configurations.’

But you do have a large laboratory with lots of complex equipment…
‘Yes, that’s true. Of course we have to be able to compete with the rest of the world. And that can’t be done quickly or efficiently without all that equipment. But the basis of nanophysics is very simple. You can essentially do it at home. The only thing you need to make graphene is a bit of sticky tape. Stick a piece of tape on top and pull it off again. Then you’ll peel off an extremely thin layer of graphite. This slice is still macroscopically thick. But the next step is to press that flake on something flat, a piece of glass for example. If you pull on the tape again, there’s a good chance that some layers of graphene only a few atoms thick will remain on the piece of glass. This is called the “Scotch tape method”. The best part is that you can get your hands on a material this way that has a great number of properties that are better than all other materials.’

Is it difficult to make a name for yourself in a new field such as spintronics?
‘I remember well how my PhD students and I were at loggerheads with a colleague on the other side of the Atlantic in 2000. We thought we knew better than him, even though our first spintronics publication was simplicity itself. Every high school student knows that the charge of an electron follows the path of least resistance. In the article we wrote that the spins of electrons do the same. That goes without saying, but we published it anyway. And you know what? The article already has 1,200 citations and that’s increasing every year!’

Your department has published some really impressive work. What has been the greatest success story in recent years?
‘One of the best results was our ability to show that you can transmit signals through an insulator. If you’re a little familiar with physics, you’re probably thinking: that’s not possible! You can’t send electricity through an insulator. That’s true, that’s the

point of an insulator. But you can send spins through it. And we recently showed that you can convert electrical spins into spin waves in insulators. They then whip over to the other side. There they can be converted into electrical spins again. So that's how you can transfer signals through an insulator after all.'

Does that research have practical applications?

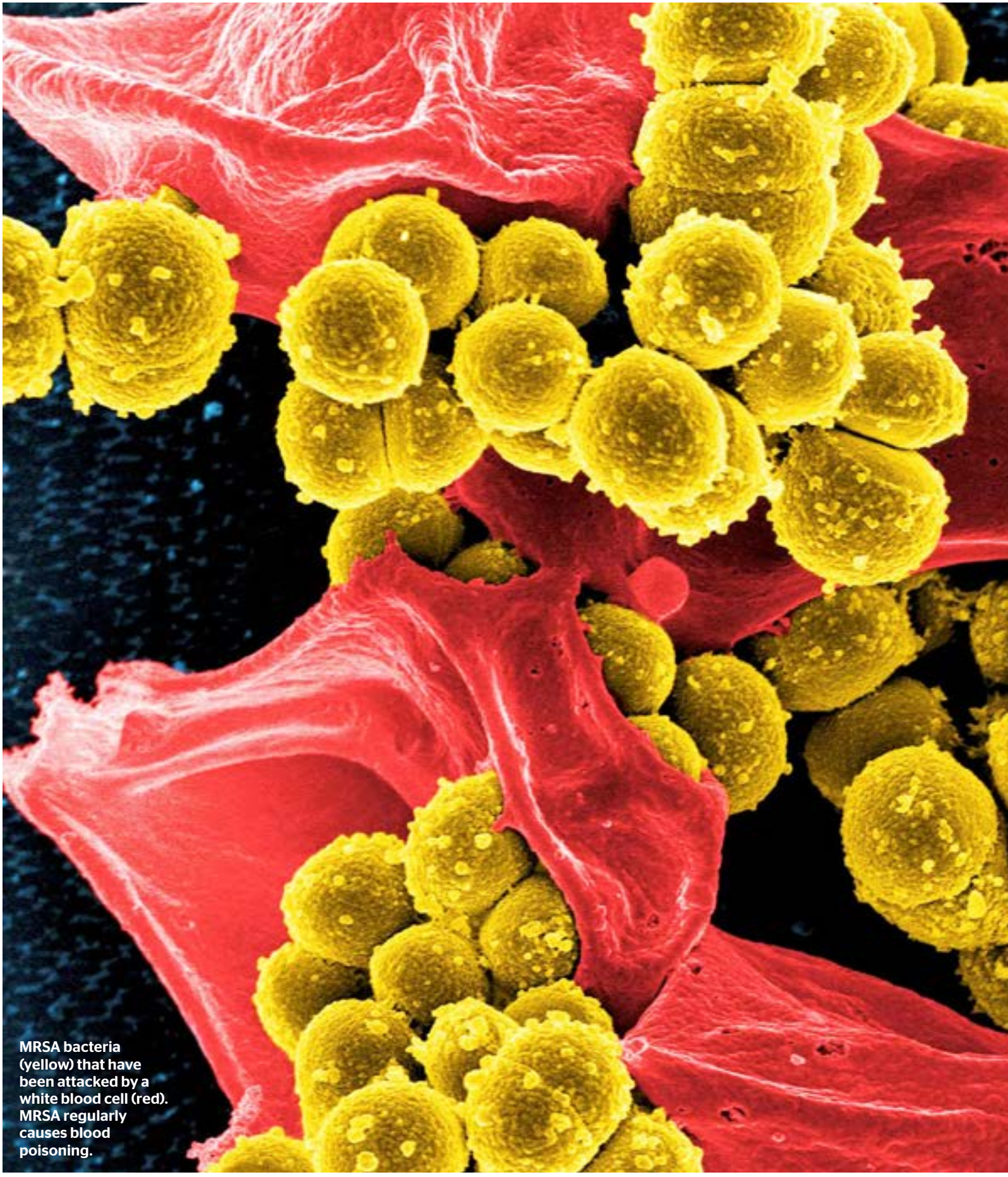
'Intel, the computer chip maker, is interested in it. They're looking for new ways of connecting circuits to each other. Usually you would have to connect them to each other electrically, but that wouldn't be necessary this way. What are the benefits of that in real life? We'll see in about ten years.'

It seems that practical applications are not something you generally focus much on...

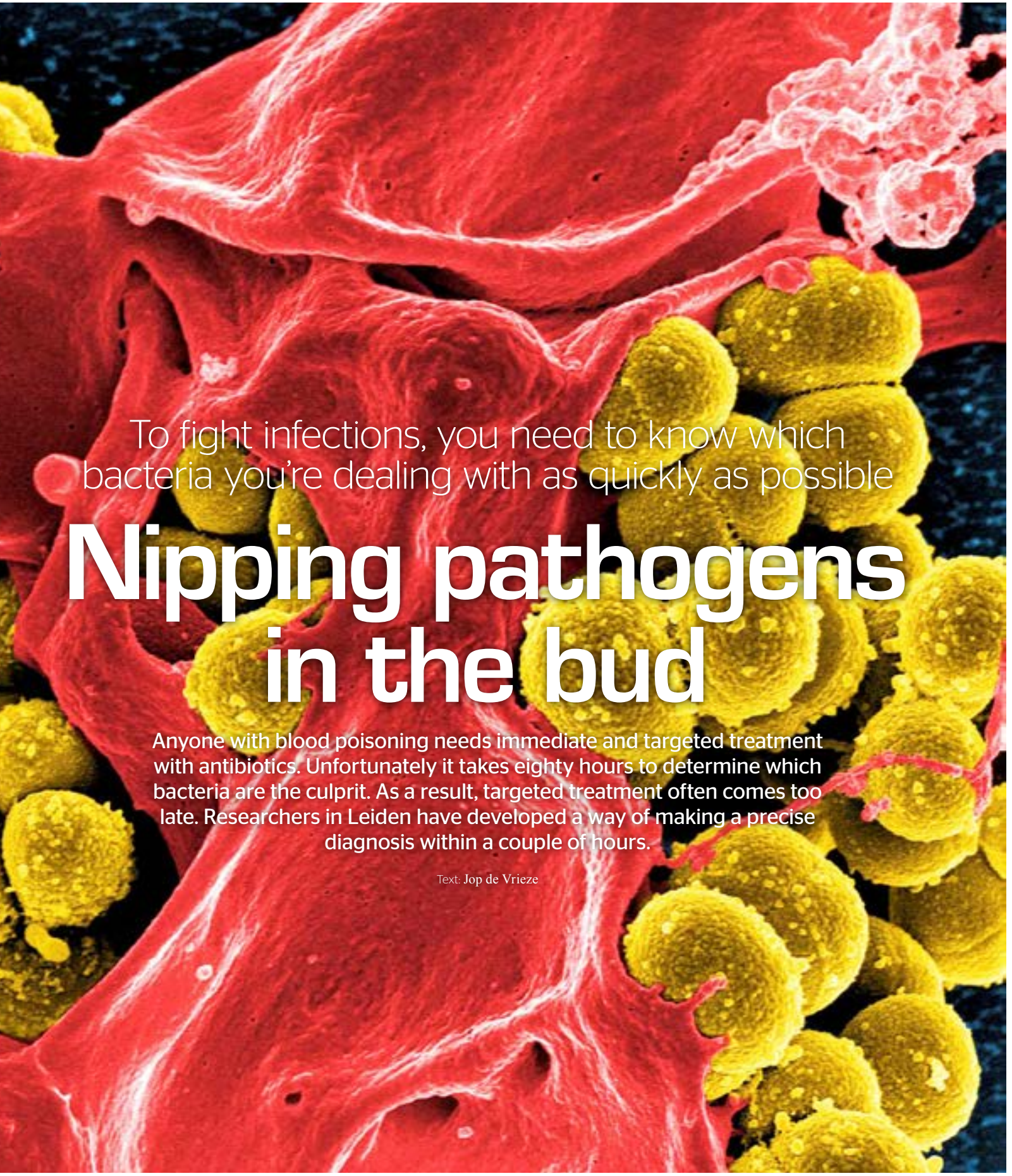
'The honest answer is: not usually. Concrete uses are often far removed from the researcher. Our research is mainly driven by curiosity. But we are certainly aware that the things we are trying out now will eventually be applied in some capacity, that there's a so-called application prospect. An effect shouldn't just occur in high magnetic fields or at extremely low temperatures. That wouldn't be much use. But we don't speculate in advance about potential applications. Having said that, graphene spintronics is on the roadmap of the European Graphene Flagship project (a project with a budget of one billion euros in which 23 EU countries have been working together since 2013, ed.). There we work together with companies and really do concentrate on applications. Not for next year, but more for a time span of ten years. It's a shame that there's less and less funding for the kind of research that's really driven by curiosity. But as far as the Spinoza Prize is concerned, that's an extremely welcome extra. Though to be honest it's the honour that really counts.'

Do you already know what you're going to do with the money?

'In the short term I want to strengthen my group in the area of research on new properties and functions of layered two-dimensional materials and devices. I especially want to work on applications that combine electronics, spintronics and photonics (the science that investigates the interaction between electrons and photons in light, ed.). That should be possible by intelligently combining new classes of two-dimensional materials with already known 2D materials, such as graphene. This may open up ways of making new, smaller components for data processing, data storage and data communication. But for the longer term I'm keeping all options open.' □



MRSA bacteria (yellow) that have been attacked by a white blood cell (red). MRSA regularly causes blood poisoning.



To fight infections, you need to know which bacteria you're dealing with as quickly as possible

Nipping pathogens in the bud

Anyone with blood poisoning needs immediate and targeted treatment with antibiotics. Unfortunately it takes eighty hours to determine which bacteria are the culprit. As a result, targeted treatment often comes too late. Researchers in Leiden have developed a way of making a precise diagnosis within a couple of hours.

Text: Jop de Vrieze

While many bacteria end up in the blood, there are too few to immediately determine which type they are

Suddenly the brother-in-law of molecular biologist Willem van Leeuwen was no more. A few days earlier he had been hospitalised with a high fever. He had blue spots all over his body, which the doctors said was happening because his blood vessels were becoming clogged. The doctors suspected endocarditis, an inflammation of the inner layer of the heart and the heart valves that had gotten so out of control that he had developed a sepsis, or blood poisoning. That's extremely dangerous because essentially blood needs to be sterile. One-third of all patients die from blood poisoning. The doctors gave him a wide spectrum of antibiotics, which only works in half of the cases. In the meantime they took blood samples to determine which bacteria were raging through his blood vessels so they could fight them more effectively. But it was too late. Even before the results came in, a number of the organs of Van Leeuwen's brother-in-law had been so damaged that his body succumbed.

Analysis takes a long time

This incident, which happened 35 years ago, made an imprint on Van Leeuwen's career, who was working at Erasmus MC at the time in Rotterdam. He found it unacceptable and incomprehensible that it took so long to determine which bacteria had caused the blood poisoning. It didn't only cost his brother-in-law his life, but another thousand or so lives a year in the Netherlands, and millions throughout the world. In developing countries, the number of cases of sepsis is increasing by ten per cent a year, especially among the elderly and babies born prematurely. The reason why it takes so long to make a diagnosis is that while many bacteria have ended up in the bloodstream, there are still too few to immediately determine which species they are. It concerns no more than a few per millilitre of blood. The bacteria therefore have to be multiplied in the microbiological lab and a test has to be run to see what antibiotics the pathogen is resistant to. All in all, that takes about eighty hours. 'So that means almost four days of suboptimal treatment,' Van

Preservative transformed

Nisin is a naturally occurring antibacterial peptide that has been safely used as a food preservative for decades. Nisin kills many bacteria, including drug-resistant 'superbugs'. Unfortunately the natural nisin molecule cannot be used as a medicine because it is broken down very quickly in the human body rendering it inactive. Working together, VIDI laureate Nathaniel Martin and Timo Koopmans at Utrecht University developed a chemo-enzymatic approach to improving the drug-like properties of nisin. Using the enzyme trypsin, which normally breaks down proteins in the stomach, they first cut the nisin molecule into fragments. They then attached a fatty acid tail to one of these nisin fragments and found that antibiotic activity was restored with the added benefit of being stable in the body. The new molecules are highly active in killing two of the most important resistant types of bacteria: MRSA and VRE. In the coming months the researchers will continue to test whether these new nisin-derived compounds are sufficiently stable, safe and active for use as a new class of antibiotic in humans.

Thanks to nisin, cheese has a long shelf life.

Willem van Leeuwen (standing) and Biosparq CEO Gerold de Valk examine the prototype of the biodetector, the machine that identifies which pathogenic bacteria is in a patient's body.

Leeuwen says. 'It's like trying to bring down a charging rhinoceros with a slingshot.'

MRSA was the guilty party

Not long after the death of Van Leeuwen's brother-in-law it became apparent that he had become infected with *Staphylococcus aureus*, an infamous bacterium that is often resistant to regular antibiotics. Which is why it's called MRSA: Methicillin-resistant *Staphylococcus aureus*. This bacterium had Van Leeuwen it its grip. For fifteen years he studied the organism in the microbiological lab at the Erasmus MC. In the meantime, a question that arose after his brother-in-law died kept gnawing away at him: can you speed up the diagnosis? The emergence of a variety of new techniques presented some hope. In 2007 Van Leeuwen started lecturing at the University of Applied Sciences Leiden. The focus there is more on applied research than work in an academic lab. That worked out well for Van Leeuwen, because he already had a specific application in mind: a quicker method for identifying the cause of infections, and in particular blood poisoning.

Hammering drops

Van Leeuwen needs about ten millilitres of a patient's blood for his method. That's added to a bottle of broth with nutrients that bacteria grow well on. The bottle is put into a machine that detects the growth of bacteria and emits a signal when the bacteria have multiplied sufficiently. On average, that takes about ten hours. One hour after that Van Leeuwen can identify the type of bacteria. He does that using a device developed by Biosparq, an engineering firm from Leiden that Van Leeuwen has worked with. The device creates drops, each of which contains one bacterium cell. It can analyse them individually, much like hand luggage is put through scanners one by one at airports.

Generating these drops was not easy, says Van Leeuwen. 'First we used a nebuliser, but that generated two to three drops at best, which is too little to

Antibiotic from Leiden

Lugdunomycin. That's the name of a promising bactericidal substance discovered in the Institute of Biology at Leiden University. L*ugdunum batavorum* is Latin for 'Leiden'. The substance is lethal for harmful bacteria such as MRSA and does not resemble any other antibiotic that has been found so far. However, there is a catch: the bacterium that produces it is 'lazy' in the sense that it produces only very little of the substance, not more than a thousandth of a gram per one thousand nutrient plates full of the bacteria. The researchers, a team led by professor of molecular biotechnology Gilles van Wezel in collaboration with his colleague Young Choi, is going all out to get the bacteria to produce more by exposing them to different substances and conditions. They're also testing whether the antibiotic has any undesired side effects on human cells, which is unfortunately the case with many other bactericidal substances. If all this succeeds, then the compound can be further tested for application as a new antibiotic for use in the clinic.

Many bactericidal substances, such as chlorine, don't have the greatest effect on human cells.

Perhaps the technology can be used in the future for urinary and respiratory infections

work with. We knew we had to do better.' A lab in Freiburg helped the scientists in Leiden to develop a tiny funnel on a microchip. Drops formed on its tip. A small hammer tapped against the funnel at a rate of a thousand times a second, causing the drops on the bottom to release and fall into the instrument where the analysis takes place. The flow was jacked up to a thousand drops a second, each of which was individually examined. 'So we don't have to grow the bacteria anymore, which saves us about 24 hours,' says Van Leeuwen.

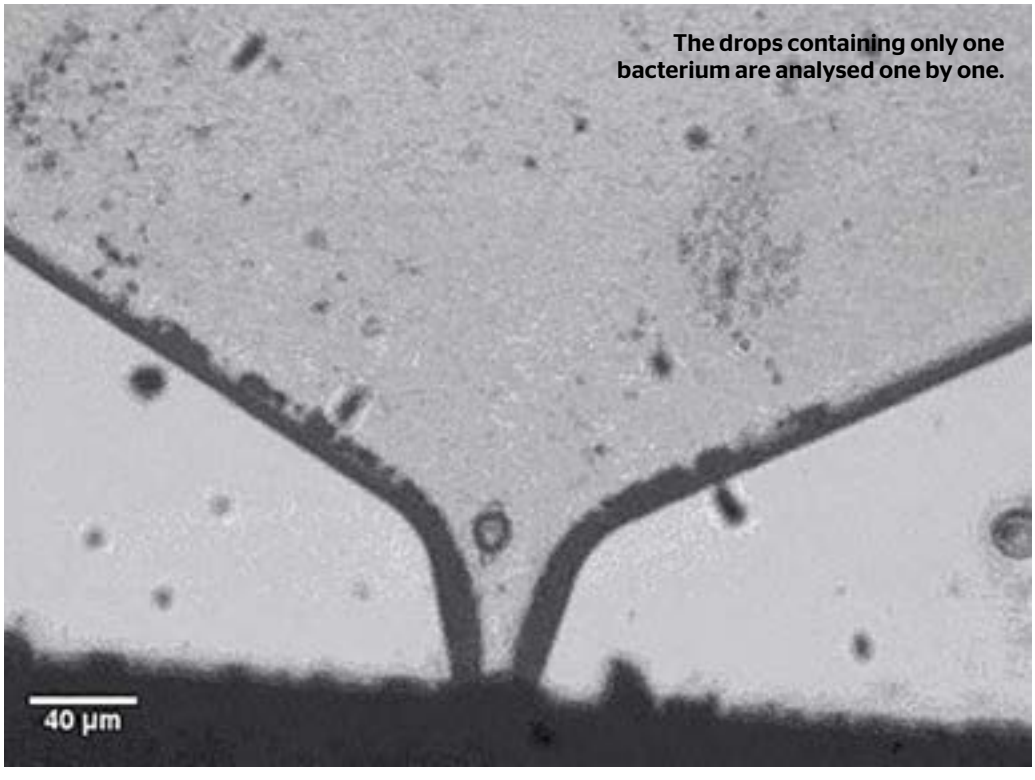
Saving millions

The analysis is conducted with an advanced electronic scale, a mass spectrometer. It analyses the weight of the different protein molecules that are present and then creates a signature that can be used to ascertain the identity of the bacteria. The number of bacteria can also be determined, which is especially important if multiple types of bacteria are present in the blood. By subsequently exposing the bacteria to increasingly higher doses of antibiotics, Van Leeuwen can determine within five hours which antibiotic should be used to fight the infection. This method means doctors can start treatment within a day. This increases the survival chances of patients by several dozen per cent. 'Sometimes a patient can be moved out of intensive care within a day. Treating one sepsis patient can easily cost between 40,000 and 70,000 euros. A quicker and better diagnosis will save millions every year and save many human lives.'

Completed database is key

Van Leeuwen's method is not ready for use in practice yet. The machine still occupies about three cubic metres of space, which is about as big as the cabin of a small delivery van. To reduce it to an acceptable format for hospital use, Van Leeuwen needs to find an investor willing to inject a few million euros into the project. Van Leeuwen is regularly visited by interested companies, but none of them has struck a deal with the researchers from Leiden yet. They are waiting for the database to be completed with the signatures of all the bacteria that can cause blood poisoning. Van Leeuwen's team is still working hard on that. It's a major task: just for *Staphylococcus aureus* a hundred different strains are needed for a reliable database. Van Leeuwen expects that it won't be long before companies decide to join once the database is large enough.

His dream is that the machine will not only be available at hospitals to save people like his brother-in-law, but that general practitioners will use the technology as well to diagnose more innocent afflictions, such as urinary and respiratory infections. That would make treatment more effective, and more targeted treatment ensures that it takes longer for bacteria to become resistant to antibiotics. 'Even now, antibiotics are blindly prescribed for urinary infections. That shouldn't be happening anymore in 2016.' □



The drops containing only one bacterium are analysed one by one.

Intelligent evolution

How do you kick start stagnant evolution again? By continuously changing the environment. Together with French researchers, Marjon de Vos and Sander Tans from the FOM institute AMOLF showed as much. Evolution takes place through spontaneous changes in DNA. But multiple mutations are sometimes needed for a new trait. If the first doesn't prove to be effective, then the next one won't happen. For a long time we believed that complex new traits could only arise when two mutations occur at exactly the same time. The chances of that are miniscule though. The researchers demonstrated that a complex change in the sugar metabolism of *E. coli* bacteria can take place thanks to continuously changing conditions. When the environment was kept constant, with either a lot or only a little sugar, then evolution stagnated in no time. But if the presence or absence of sugar changed, then the evolution did continue. A mutation that has a negative effect in 'normal' conditions may well have a positive effect in other conditions. For example, a mutation can cause the production of an important protein to decrease, but if the conditions change so that this protein is no longer needed, then that is an advantage. That paves the way for the next evolutionary step towards complex new traits.

It's all in the fold

Letter writers in the past would have thought it inconceivable: their post, preserved in a trunk made out of seal leather, being put under a scanner that reveals all their epistolary secrets. It concerns about 2,600 letters from the seventeenth century that never reached their recipients. 'We're going to use the scans to see if we can establish a link between the way that the letters were folded and sealed and their content,' says Nadine Akkerman (Leiden University) from the 'Signed, Sealed, Undelivered' team: 'In the seventeenth century the letter itself was also the envelope. And it appears that the person who folded the letter into an envelope didn't do it randomly.' Love letters, for example, were often folded in the shape of a diamond. And the more secret the letter's contents, the more ingenious the method of folding and sealing. A crucial element of the research is the super scanner that's being used. 'It not only displays the text, but also the folding lines, the texture and the watermarks,' says Akkerman. The analysis from the scans is about to begin. Anyone interested can play detective too. 'They will be available online so that anyone who wants to can help us search for correlations.'

The letters come from the postal trunk of Simon de Brienne, who became postmaster in The Hague in the late seventeenth century. The trunk has been kept at the Museum voor Communicatie in The Hague since 1926.

Most of the letters in the trunk were sent from France to the Netherlands. Each one of them was personally folded and sealed.

If you want to help unravel epistolary secrets, visit brienne.org.

Railway researcher Anthonie Boogaard (left) connecting his measurement equipment.

Waiting for a train in the name of science

Tuning in to the tracks

It's busy on the Dutch railway. Maintenance and repairs cause delays, which rail passengers are constantly bemoaning. That's why scientists are studying faster ways of fixing railway disruptions. Anthonie Boogaard's measurement equipment 'hears' defects in the tracks. *Experiment NL* tuned in with him.

Text: **Melanie Metz** / Photos: **Adrie Mouthaan**

Sensors under the tracks should discover wear and tear before railway services come to a standstill

Anthonie Boogaard is standing next to the railway track in his warm work clothes near a summery Westerpark in Amsterdam, where people are parading themselves with sunglasses perched on their noses. The engineering dynamics researcher from the Delft University of Technology 'listens' with his measurement equipment to vibrations caused by trains. That's how he aims to track down potential defects in the rails, because they show up in the vibrations. The project that Boogaard is working on is called 'Dr. Track'. It's part of the ExploRail programme, a partnership between railway operators ProRail, Technology Foundation STW and NWO (see box 'Railways doctors'). Every month Boogaard stands next to the railway line for a few hours to do his fieldwork. What does he do exactly? And wouldn't he rather be doing it behind a computer?

Safety first

'Raise your arm in the air when a train approaches.' Safety officer Rick Ruiter sums up the safety rules before we're allowed near the railway tracks. 'Then the train driver will know that you've seen the train and that you won't just wander onto the tracks.' Boogaard knows the rules by heart. He's been doing research along the railway tracks for four years now. The photographer and I put brightly coloured safety vests on top of our clothes and shoes with steel toes. We watch with envy as people in the park walk around in flip-flops. 'Stay behind the fence, and under no circumstances go onto the tracks,' says Ruiter strictly as he opens the gate to the tracks. 'Stay in front of me.' Boogaard goes first. He has a cart with a generator to power his equipment. We walk in a goose step to the measurement station. A train zooms by a few metres away. You feel the airflow. Obediently we raise our arms. The driver, seated high in the train, waves back.

Wear and tear on the tracks

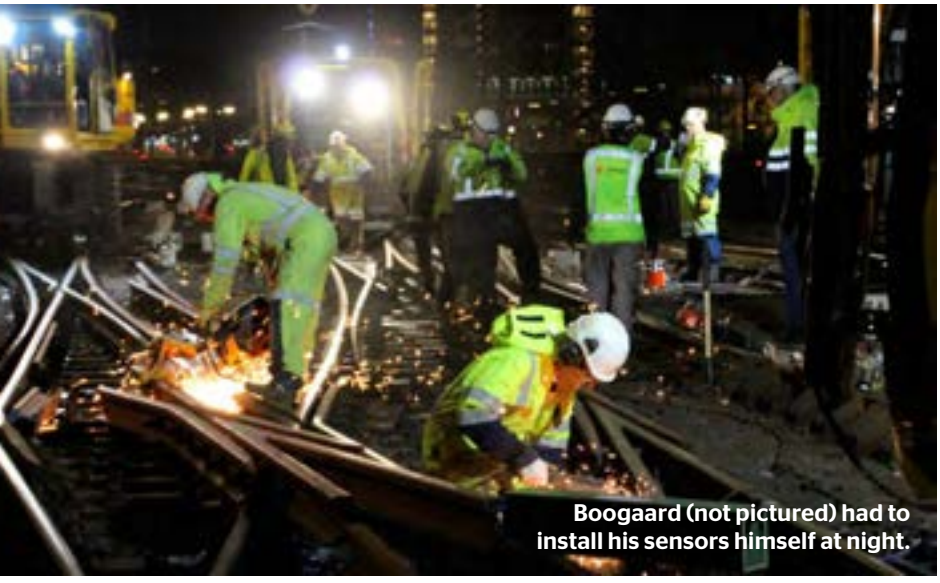
After a quarter of an hour, Boogaard stops next to a grey metal casing with a TU Delft sticker on it. 'In here is a simple computer that records these vibrations from the sensors,' he explains. Then he stops as another train roars past. Everyone raises their arms. Boogaard continues. The sensors, accelerometers, are the 'ears' of the rails, he says. They capture the vibrations of the train on the track and send the measurements to the computer in the grey casing. 'These sensors are hidden under tracks, look…' He points to the tracks. 'Hey, not too close,' the safety officer warns. We step back. Apart from a candy wrapper there's little to see on the rusty rails. 'If you look closely, you'll notice wires coming out of the rails.' Indeed, if you look closely. The sensors are in a well-chosen place. Boogaard points to the tracks, one of which bends to the left. 'Here's a set of points, where two railway lines cross each other,' he says.

He gestures to the junction where the rails converge and form a pointed triangle. 'That part's called a frog. There's often damage here because there's a slight difference in height between the two rails.' As time passes, the iron wheels of the trains cause wear and tear and imperfections. The sensors are at this vulnerable point so they can discover the damage quickly.

Characteristic sound

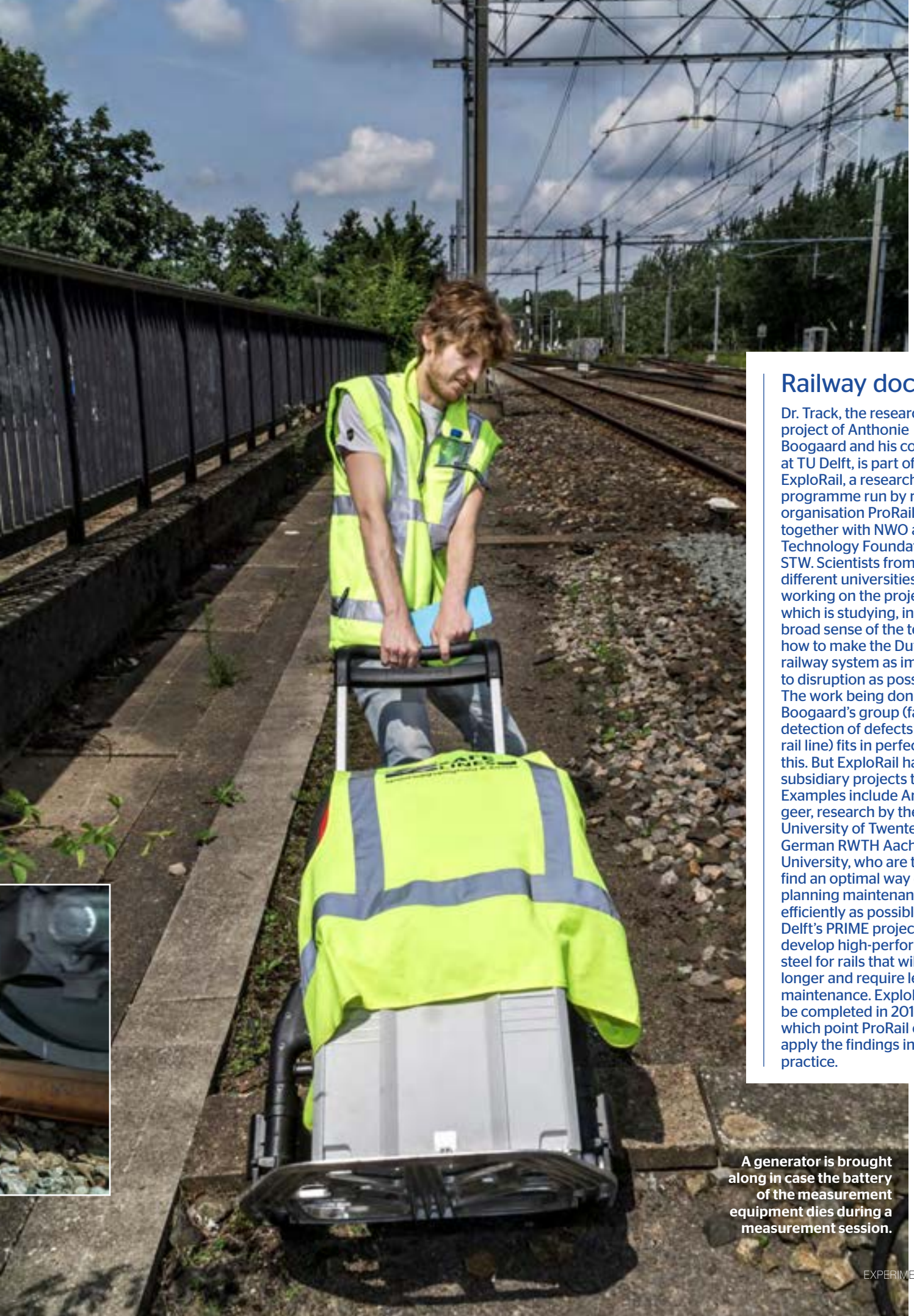
Boogaard rummages in his bag. 'Today I'm going to use an iPad for the first time.' The computer in the casing should now send the vibrations from the track to the tablet. 'I hope it works. The software in the casing is brand new,' he says. The screen remains black. Meanwhile, a train thunders past again. We raise our arms dutifully. 'They probably think he's playing Pokémon Go,' the safety officer chuckles. Boogaard laughs but doesn't take his eyes off the tablet.

Then lines appear on the screen: the sound vibrations, converted into graphs. 'There you go,' Boogaard mutters. He taps the touchscreen. 'Look, here's where I enter what kind of train it is, a freight train or a double-decker. The one that just went by was a "sprinter", a small train. That shows up in the graph.' He points to the lines on his screen. 'There's a peak for every wheelset.' Whenever the train wheels hit the track, you get a reading. 'The carriages of larger trains have more pairs of wheelsets, so it sounds much different. That also produces different vibration graphs.' So each type of train has its own characteristic sound. Boogaard wants to explain more, but ▷



Boogaard (not pictured) had to install his sensors himself at night.

The sensors under the railway measure the vibrations caused by train wheels roaring by on the tracks.



Railway doctors

Dr. Track, the research project of Anthonie Boogaard and his colleagues at TU Delft, is part of ExploRail, a research programme run by railway organisation ProRail together with NWO and Technology Foundation STW. Scientists from different universities are working on the project, which is studying, in the broad sense of the term, how to make the Dutch railway system as immune to disruption as possible. The work being done by Boogaard's group (fast detection of defects in the rail line) fits in perfectly with this. But ExploRail has other subsidiary projects too. Examples include ArRangeer, research by the University of Twente and the German RWTH Aachen University, who are trying to find an optimal way of planning maintenance as efficiently as possible. TU Delft's PRIME project aims to develop high-performance steel for rails that will last longer and require less maintenance. ExploRail will be completed in 2017, at which point ProRail can apply the findings in practice.

A generator is brought along in case the battery of the measurement equipment dies during a measurement session.

You can't see minor imperfections with your naked eye, but you can hear them

▷ another train passes, a long Thalys. A graph appears on the screen, and this time it does indeed have more peaks than the small train before. More wheels, more peaks, more noise.

Preferably in real life

During each measurement session Boogaard gathers information from about fifteen trains. Sometimes he stays for an hour. But sometimes there are delays, causing him to wait for trains for three hours. 'I always have a case with me with tools and things. If I get tired I use it as a seat.' Is there time to eat anything? 'Well, sometimes I see the toilet being flushed as a train passes… Then suddenly something splashes onto the tracks. So you wouldn't enjoy it anyway. I stick to a bottle of water.' Sometimes Boogaard gives home a quick call. 'I let my three-year-old daughter watch a passing train on Facetime sometimes. That really impresses her. She's never been in a train.' Doesn't the railway researcher ever take his family on the train? 'Uh, no. The car is more convenient with two small kids. My youngest is six months old. And I spend enough time waiting for trains for this research.'

An additional sense

The sun gets brighter and brighter. The photographer is walking around with his camera, puffing. I'm cooking inside this synthetic safety vest. Beads of sweat cover the safety officer's forehead. Boogaard still looks fresh though. 'Okay, I have what I need,' he says enthusiastically. A variety of trains have passed,

Boogaard explains something to the editor, which isn't easy with all these noisy trains flying by.

What's taking the train so long?

The most important reason for ProRail to conduct research is to keep train passengers happy. Defects on the track and in trains frequently cause delays. Based on travel information published by the NS, the site rijdendetreinen.nl has been monitoring the reasons for disruptions since 2011. The top five, respectively, are 'train defect', 'points failure', 'signal failure', 'collision with a person' and 'repair works'. Of course with three million journeys on the railway network in the Netherlands it's no wonder that something goes wrong sometimes.

Among the welders

The sensors that Anthonie Boogaard uses to take measurements are hidden under the tracks. Boogaard installed them there himself. For that, he had to join railway workers at night, because no one's allowed to go onto the train tracks during the day, not even to work on them. Boogaard went along with the railway workers from Strukton, who do the regular railway maintenance. 'A special experience. I was working on my own project among the welders.' Initially the railway men thought it was strange that a scientist would come along to tinker on the tracks. 'But gradually they realised I was okay,' Boogaard says. At which point they would come and have a chat with me. And criticise how I was fastening the sensors, hah hah.' The knowledge of people working on the ground is usually useful, says the TU Delft researcher. 'That's what's interesting about this research. I have already played the sound vibrations to experienced railway people a few times.' And their years of experience meant they could immediately tell when something was wrong. 'Someone would say: "The track's uneven." Which actually turned out to be the case. I want to convert this practical knowledge into objective measurement.'

◀ **The vibrations can be read on the tablet in a graph.**

▼ **Wires on and between the rails are hardly noticeable, if at all.**

from sprinters to large double-deckers, so he's happy. What now? 'I'm going to compare all the data on the computer.' As soon as he has gathered enough information from an undamaged railway line he has data he can compare. 'I can use it to make a kind of filter that you can use to recognize anomalies. If they're present, then you know that there's damage.' Is 'listening' to tracks practical? Can't you just look and see if something's broken? 'Some minor damage, like an imperfection, is not always easy to spot. But you can hear it,' Boogaard says. Moreover, you can continuously measure vibrations, and put these measurements through a program to see if there are anomalies. 'That's difficult to do with visual control. You'd have to watch thousands of video images to spot an anomaly.' Not that you'd never have to look at the railway tracks again once you use his system. 'But this adds an additional sense to the equation.'

Measuring from the train

What's the next step? First a cheaper version of the measurement equipment that Boogaard uses needs to be developed. It now costs a cool 30,000 euros. He's working with colleagues on an instrument that should only cost 500 euros. 'That device is a little less sensitive than the equipment I'm using now. But it's really meant to be used in a lab, and it's extremely accurate.' A simpler tool is fine for measurements along the railway. Boogaard is currently testing the prototype's sensitivity. 'We put the sensors under a bicycle path to see whether our new, cheap device can pick up sound as well as the expensive one.' That seems to have gone well. The new device is not only less pricey, but it also has more options. 'Indeed, the goal of the project is to be able to take better measurements from a moving train.' That is now happening with the *CTOmeetrijtuig*, an old train-cum-test coach for research. 'You can place a simpler measurement device on regular passenger trains. Then you can take two simultaneous measurements, one from the train and one from the tracks.' If these measurement devices keep an eye on many places along the railway in the future, then ProRail will be able to spot defects quickly. 'Before more severe damage is done.' In the end, that means money saved and fewer delays.

Covered in dust

Back behind the fence, everyone puts on their safety vests again. Boogaard washes the dust off his hands under the faucet in the back of his van. He's not bothered by the dirt and noise. 'I'm too busy for that. Checking equipment, transcribing data. And sometimes the system doesn't work. Then I have to repair it.' Can't he just watch computer simulations in a comfortable lab? 'I do that too. And that's what many researchers stick to doing. They may do a test in the field once. That's fine, but I prefer testing whether something really works in practice.' Is he a train freak? 'Not really. I didn't have model trains when I was young. I just like measuring, preferably something tangible, something everyone knows and uses. Like a train.' If that means spending a few hours in the dust, no problem. □

MORE INFORMATION

explorail.verdus.nl: site of the railway research project.

How did vertebrate animals get their teeth?

Open wide

Almost all vertebrate animals have jaws and teeth. Different species have teeth suitable for a variety of menus. But which animal developed the first set of teeth? Palaeontologist Martin Rücklin has been looking into it.

Text: Marc Koenen

Halfway through the interview, palaeontologist Martin Rücklin apologises. 'I'm sorry for speaking so quickly, but once I get started on this, I can't seem to stop.' Rücklin, affiliated with the Naturalis Biodiversity Center in Leiden, has already explained at breakneck speed what his work focuses on: the evolution of jaws and teeth since the emergence of vertebrates. Rücklin started this work in 2008 at the University of Bristol in the United Kingdom. He found fossils that had been collected forty years earlier in the Canadian North Pole. They were the remains of a roughly 410 million-year-old fish, *Romundina stellina*. That was one of the first animals to have a jaw. What struck Rücklin was the fact that there were several plates a few millimetres large. They had a rough surface, a bit like sandpaper. Where were these plates when the fish was still alive? Rücklin was able to see on photos that Parisian colleagues had taken of other *Romundina* fossils that they had found in Canada: they had been in the animal's mouth. So the next question was, what were they doing there?

You have to treat rarities with care. That's why the research had to ensure that the plates remained intact. So you can place them under a microscope, for example, but then you won't see what's inside the plates. Together with his colleagues from Bristol, Rücklin therefore exposed one of the plates to high-energy X-rays that the Paul Scherrer Institute in Switzerland generates with a so-called 'synchrotron'. It concerns radiation that's too strong for medical use in the human

DAGGERS
Carnivores, like this polar bear, often have dagger-like teeth to kill their prey with. The 42 polar bear teeth are larger than its cousin's, the brown bear. The latter lives in areas where plant food is available too.

REGENERATOR
Crocodiles tear their prey into pieces and often lose a tooth in the process. They don't care. They continuously regenerate their teeth.

DEEP-SEA TEETH
The humpback anglerfish's mouth can become as wide as its entire body. Because its teeth point backwards, prey have difficulty escaping. This fish lives in the deep sea.

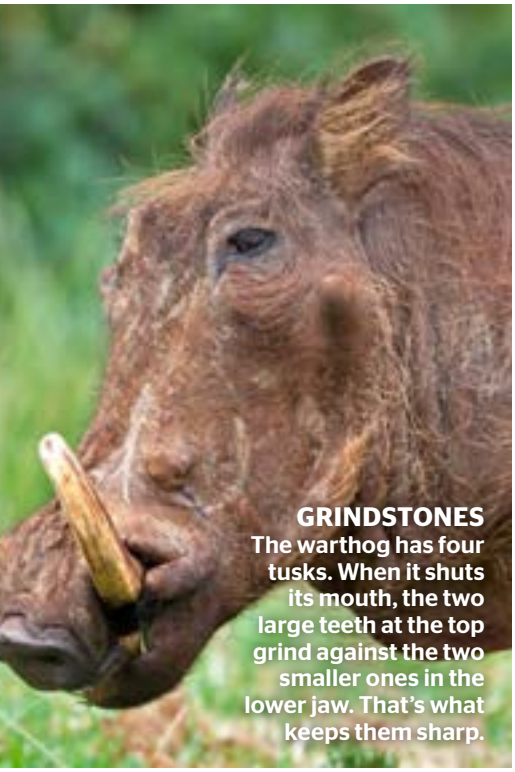
The fossil tooth plate of the fish *Romundina stellina*. The X-ray scan shows bumps, made of dentine and enamel. These are the world's oldest known teeth.

NO LAUGHING MATTER
Many plant eaters, like the horse, have incisors in the front of their mouth. It 'cuts' the grass with them which it then grinds with its molars.

IRON TOOTH
The coypu's incisors are orange because the enamel contains iron. It's not clear what the function of that is.

SIEVE TEETH
The crabeater is a seal that lives off krill, small shrimp-like animals. When it closes it mouth, there are small spaces between the teeth, an excellent sieve to filter the krill with.

INJECTION BITE
The rattlesnake's poisonous tooth is as hollow as an injection needle. When the snake bites, it automatically inject poison into its prey.



GRINDSTONES
The warthog has four tusks. When it shuts its mouth, the two large teeth at the top grind against the two smaller ones in the lower jaw. That's what keeps them sharp.

The intense X-ray radiation shows tissues inside the fossil

▷ body, but which is applied in many branches of science, for example by geologists who want to see which minerals are inside a piece of stone. But palaeontology seems to be benefiting from the technology too. 'The intense radiation produces scans with such good resolution that you can see different kinds of tissues in the plates.' Rücklin says. Combining thousands of X-rays that he made of the plate enabled him to visualise the tiny bumps that make the plates resemble sandpaper. The bumps seem to have a core of dentine with a layer of enamel on top of it. The teeth of animals now, including humans, have a similar structure. In other words, the fossil plates are part of the oldest set of teeth that we are aware of today.

The images also suggest that the teeth plates were formed around a 'pioneer tooth'. Once the fish grew larger, new pioneer teeth appeared in the bordering tissue that merged into the growing tooth plates. 'This pioneer tooth is very similar to the scales of a fish,' says Rücklin. 'That's why we think that teeth and fish scales have a common history. Don't get me wrong: we're not saying that teeth are a kind of scale, but that they may well have had some kind of common ancestor.' To gain more of an understanding of that, he's going to study the fossils of even more primitive vertebrates, both jawed and jawless ones. He's happy that he can do this in Leiden. 'When I look out the window here, I see in the distance the academic hospital, which is putting their scanning equipment at our disposal. The Bio Science Park is here too, where the Institute of Biology Leiden and various other companies and institutions do biomedical research. You can add palaeontologists to the list now. These partnerships in the Netherlands are great. I feel right at home here.' □

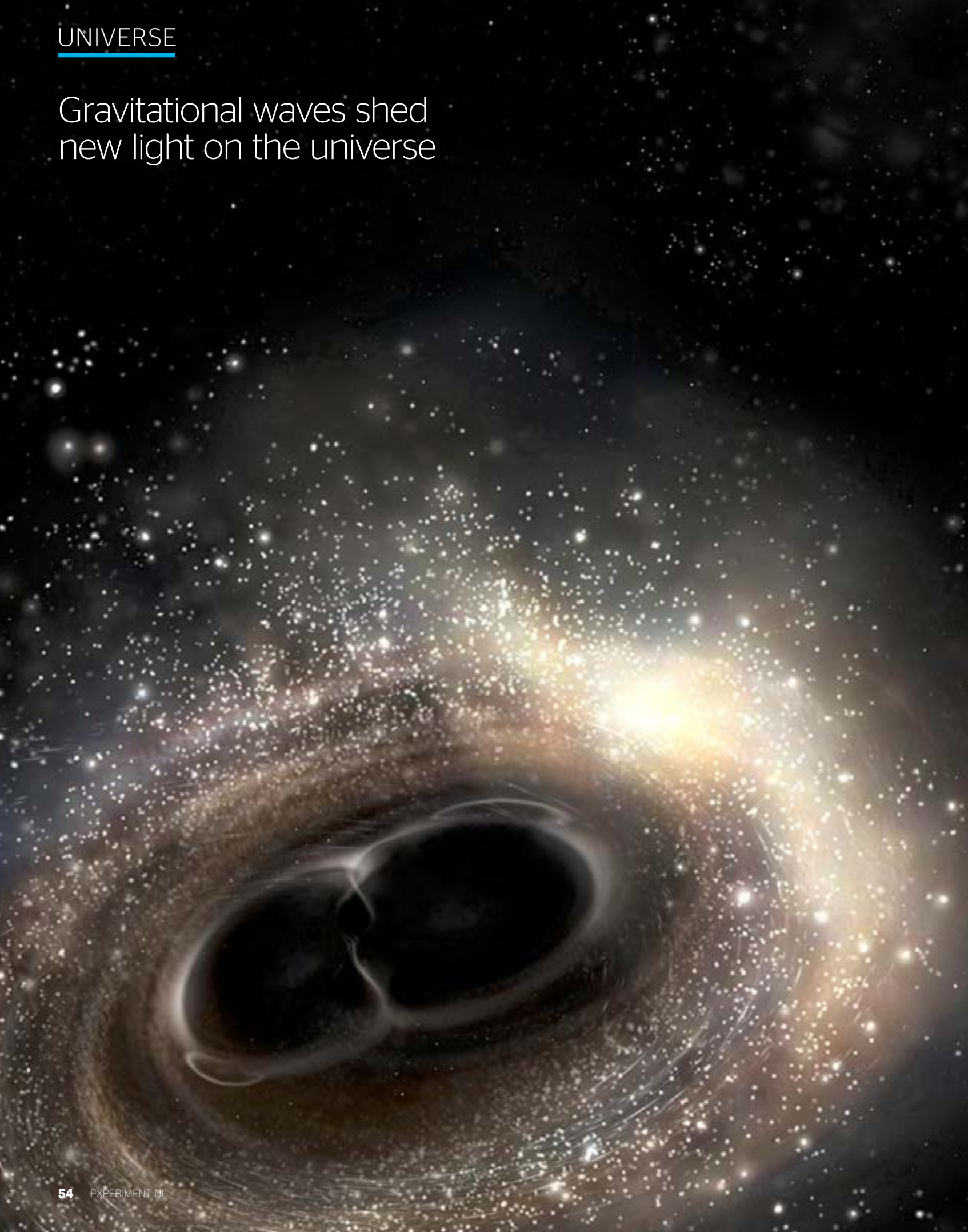
MORE INFORMATION

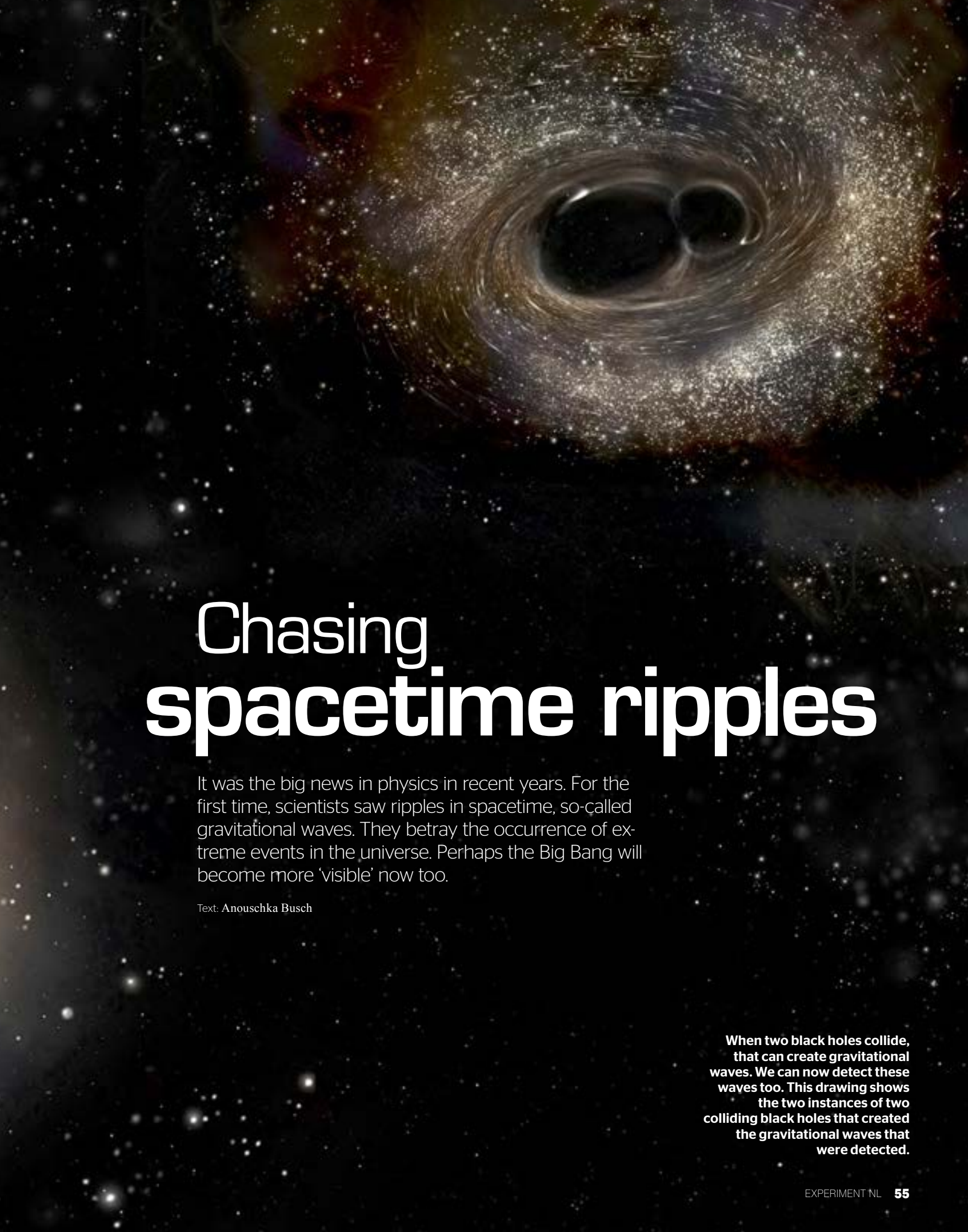
http://tinyurl.com/huf2gf8: Naturalis press release about the discovery of the fossil tooth plate.

CONVEYOR BELT
Sharks keep developing new teeth. They grow in rows behind each other, like a kind of conveyor belt of teeth. A shark can go through 30,000 teeth in its lifetime.

WHITE WEAPONS
Look out for plant eaters like the camel. It may not eat you, but angry camels have killed a person with their teeth on more than one occasion.

Gravitational waves shed new light on the universe





Chasing spacetime ripples

It was the big news in physics in recent years. For the first time, scientists saw ripples in spacetime, so-called gravitational waves. They betray the occurrence of extreme events in the universe. Perhaps the Big Bang will become more 'visible' now too.

Text: Anouschka Busch

When two black holes collide, that can create gravitational waves. We can now detect these waves too. This drawing shows the two instances of two colliding black holes that created the gravitational waves that were detected.

When two extremely compact and heavy objects spiral around each other they generate waves in spacetime

In retrospect it was a historical moment: 14 September 2015, just before one o'clock in the afternoon (Dutch time). That's when a surprised data analyst in Hannover, Germany circulated an e-mail asking if what he was seeing was really true. In the US, the home base of the LIGO detectors that are searching for gravitational waves, everyone was still in dreamland because of the time difference. But the European members of the LIGO consortium were staring at their screens in disbelief. One of the computer systems that filtered out potentially interesting signals from all the 'noise' that the detectors also pick up from the universe had signalled something truly exceptional at 10:51 AM. A squiggly line lasting 0.2 seconds which, if the graph were to represent a soundwave, would sound like a chirp. That's how scientists who have been looking for this distinctive signal for years describe the sound. Was this really it, the first gravitational wave to be observed directly? It seemed almost too good to be true. Only two days before, the LIGO detectors had been rebooted after a major upgrade. And now, before the research was even formally launched, there was already a signal? A signal, moreover, that was much crisper and clearer than anyone could ever have imagined?

No joke

The first thought was that this was a practical joke, or a simulation that had somehow accidentally ended up in the detectors' computer data. The LIGO-Virgo Detection Committee, whose task it is to review the processes, weren't about to take any chances though. The signal wasn't accidental 'noise', that much was clear from the outset. 'These signals have a very specific form. The chances of something like that happening by accident is smaller than one in several million,' says Jo van den Brand, initiator and head of gravitational wave research at Nikhef, the National Institute for Subatomic Physics, part of NWO, and one of the fifteen specialists who sat on LIGO's Detection Committee.

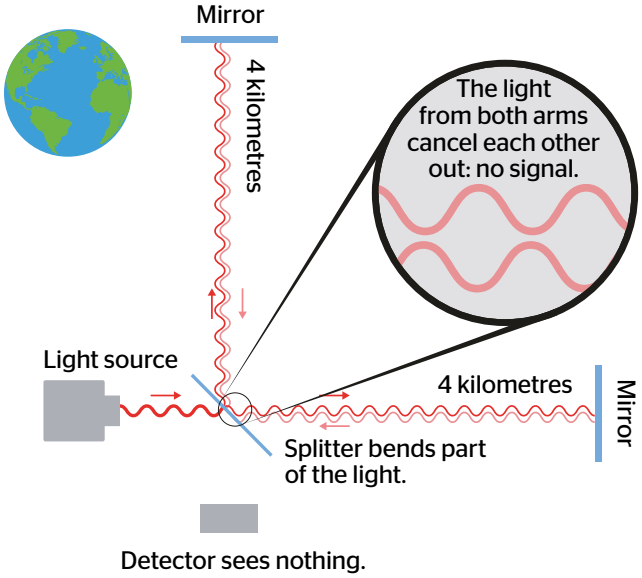
Nevertheless, it took about three months for the committee to definitively rule out any potential errors, malfunctions, fake signals or sabotage and conclude that the signal was real. 'What we had seen was the most powerful event ever observed in the universe,' says Van den Brand. The signal seemed to be emanating from the merger of two black holes, 29 and 36 times the mass of the sun and one and half billion light years away from Earth. These holes spiralled closer and closer towards each other, collided and transformed into a single spiralling black hole 62 times the mass of the sun. And all that happened in a fraction of a second.

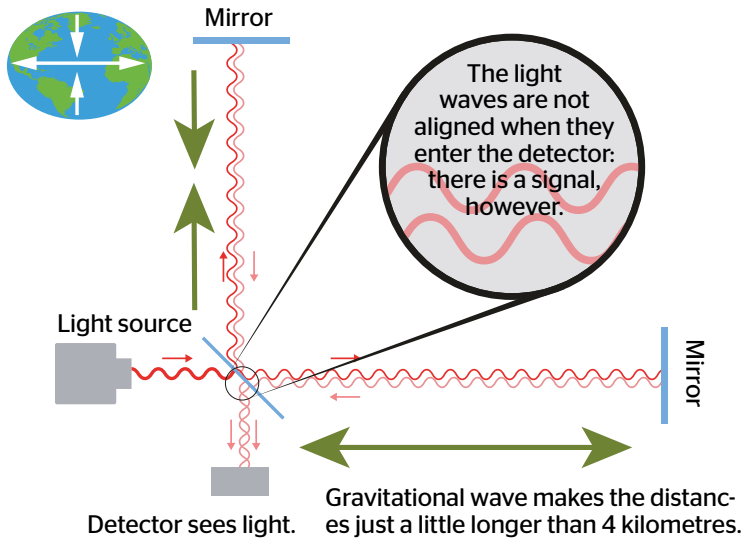
Giant instruments

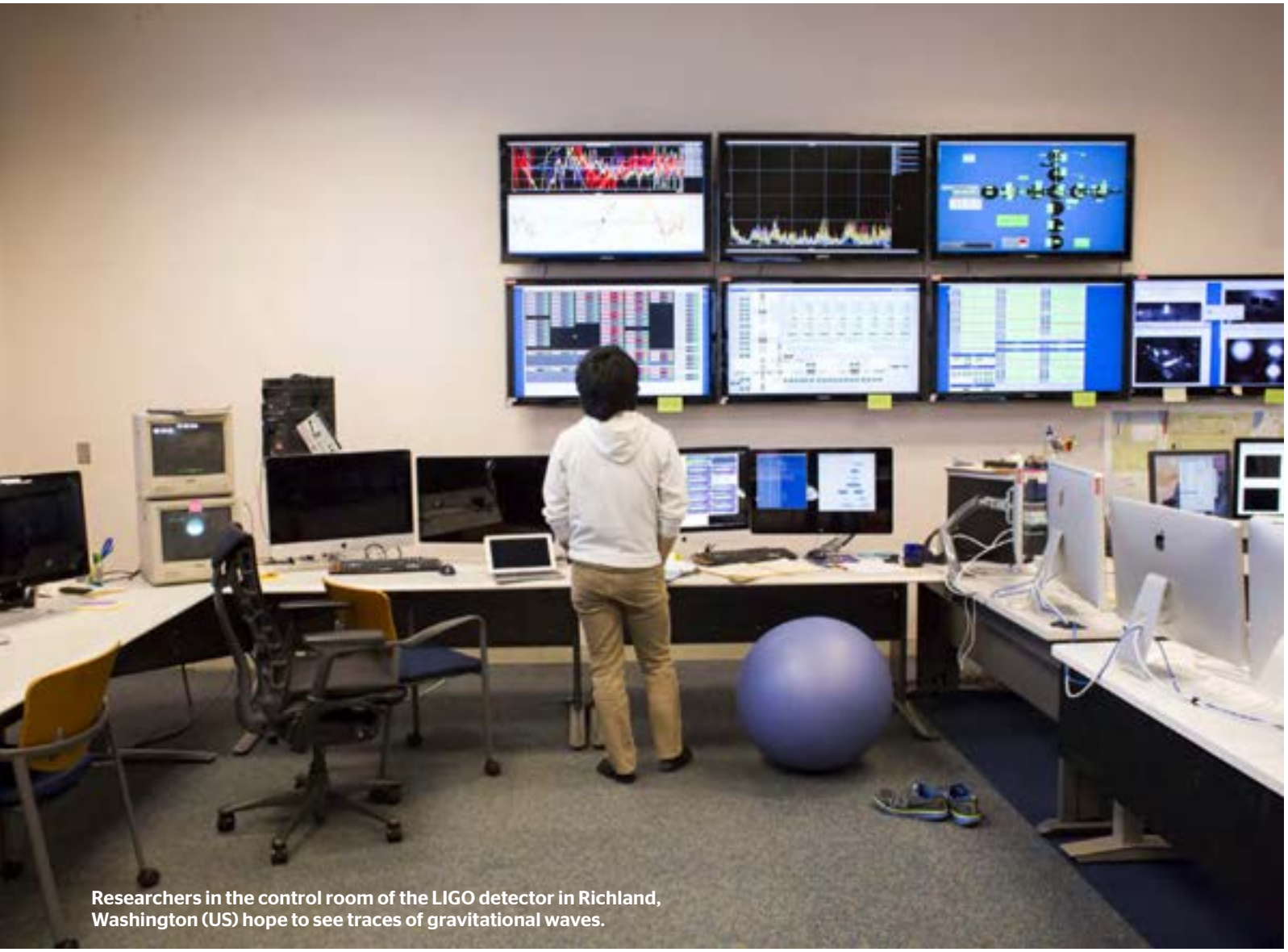
Gravitational waves weren't an unknown phenomenon at the time. Albert Einstein's theory of relativity had predicted their existence in 1915. Two extremely compact and heavy objects spiralling around each other quickly generate waves in spacetime. These waves will move outward, much like circles of water when you throw a pebble into a pond. But the existence of these ripples had only been demonstrated indirectly at that

How do you see gravitational waves?

To detect gravitational waves, scientists use the properties of light waves. In certain conditions, light waves can cancel each other out when they meet. In an interferometer, laser light is entered into the machine and split into two beams. At the end of the instrument's arms, both laser beams reflect against a mirror and return to one place together. The waves of laser light are usually exactly opposite each other. That's why they cancel each other out perfectly when they converge. The detector doesn't see anything at that point and has therefore not picked up a gravitational wave. If a gravitational wave comes near the interferometer, then one arm will become slightly longer and the other slightly shorter. The two laser beams then travel slightly different distances and won't cancel each other out perfectly anymore. As a result, a tiny bit of light will escape the interferometer which is recorded by the detector. There's a signal!







Researchers in the control room of the LIGO detector in Richland, Washington (US) hope to see traces of gravitational waves.

point. Because how do you detect gravitational waves that move through everything without leaving a trace? The only thing that tells you that a ripple is passing through is that the environment stretches and contracts slightly. Unfortunately that doesn't only happen to the environment, but also to the measurement instrument. So a ruler, for example, would be useless for measuring the wave because it too would stretch. What you need is something that always remains constant: the speed of light. Interferometers use it. In the 1970s, researchers thought to themselves, why not use it to measure the stretching and contracting (see also the box 'How do you see gravitational waves?'). The only catch is that the measurement instruments have to be several kilometres in size.

The news broke in February 2016: the waves exist!

A growing project

It wasn't until the 1990s that scientists managed to persuade the National Science Foundation in the US to fund the interferometers, which cost hundreds of millions of dollars. In 2001, two LIGO interferometers became operational: one in the state of Washington and one in the state of Louisiana. Laser beams are ▷

Measuring problem

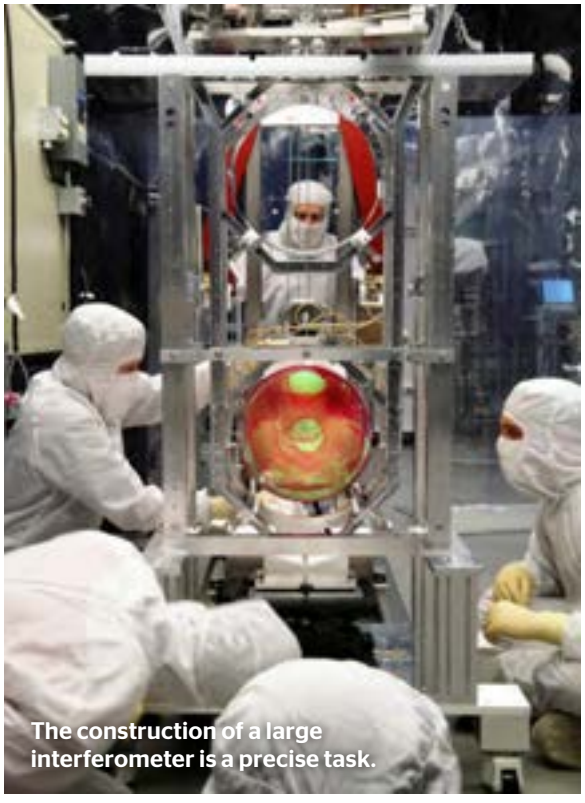
A great deal of technical ingenuity is needed to build a gravitational wave detector, because gravitational waves are extremely small. As long as you're not too close to the source, of course, because then they are pretty fierce. And deadly: at the source they stretch you to twice your length and then contract you till you're half your original size. But when the waves reach the Earth after billions of years, they've become so weak they barely stretch and contract objects anymore. And barely really means barely: the difference in size is less than an atomic nucleus, or about on billionth of a billionth of a metre of difference. Extremely accurate precision instruments such as interferometers are needed to measure these kinds of differences.

‘This shows that new things are always still possible. It’s really not as if science is finished.’

▷ reflected back and forth from mirrors in two 4 kilometre-long arms standing perpendicular to one another. If the distance between the mirrors becomes longer or shorter as the result of a passing gravitational wave, the detector will notice it.
In 2007, the Italian-French-Dutch Virgo interferometer, which was built in Italy, became operational. More than a thousand researchers from eighteen countries worked on the gravitational wave project. Today, more than 130 institutes are involved in it, including Nikhef in Amsterdam, which was one of eight core institutes to make a significant contribution to the data analysis and upgrade of Virgo.

A new astronomy

The great excitement about the first detection of a gravitational wave was not solely about the discovery itself. This detection opened up completely new areas for scientific research. ‘Gravitational waves have given us a whole new way of conducting astronomy,’ says Gijs Nelemans, astronomer at the Department of Astrophysics at Radboud University Nijmegen. Nelemans is partly responsible for the astrophysical interpretation of these measurements. ‘Almost everything that we know so far about the universe comes from electromagnetic radiation: light, radio waves or X-rays. Gravitational waves enable us to discover new objects, things that emit no or very little radiation. And we can study objects that we already know in a new way, so we are also gaining new kinds of information.’
Meanwhile, a second space ripple caused by colliding black holes has been detected and officially confirmed. Nelemans hopes that a collision between two neutron stars will be detected soon too, or one between a neutron star and a black hole. Because unlike black holes, that would also emit an optical, X-ray or radio signal as well. That would be interesting data for astronomers, because they could compare gravitational measurements with measurements based on electromagnetic radiation.



The construction of a large interferometer is a precise task.

Testing the theory of gravity

Scientists hope to learn more about the Big Bang from gravitational waves. Instruments that measure electromagnetic radiation cannot look back further than 380,000 years after the Big Bang. That’s the moment when the universe became transparent to light. But gravitational waves may enable us to look even further back in time, until a fraction of a second after the Big Bang. That’s really the very beginning.
Gravitational waves also provide physicists with a unique opportunity to test Einstein’s theory of gravity under extreme conditions. For that purpose, Nikhef developed data analysis methods and software. ‘We know that Einstein’s explanation of gravity cannot be the whole story,’ says Van den Brand, ‘because that explanation is at odds with quantum mechanics. There are only two natural systems in which both gravity and quantum effects play a role: the Big Bang and black holes. Now we can take measurements for the first time instead of just talking about it abstractly.’
Until now everything physicists have seen corresponds with Einstein’s theory. But with only two measurements the analyses are still far from accurate. As more collisions are detected, Einstein’s theory will be increasingly put to the test. And perhaps the day will come when this theory shows cracks and quantum effects will start to play a role.

More in store

One thing’s for sure: the second detection won’t be the last. Moreover, the coming decades will see new and improved gravitational wave detectors. The Virgo detector has already been improved, and new detectors are being built in Japan and India. The LIGO detectors will be upgraded again in 2021.
Einstein Telescope is also a high priority project in the world of science. It is the intended successor of Virgo. It will be an underground detector with arms ten kilometres long. It will not only enable scientists to see larger objects, but also to see much further. Finally, there’s also the LISA, a plan for an interferometer in space with ‘arms’ of approximately one

◀ The LIGO detector in the American state of Washington has two arms, each of which is four kilometres long, in which laser light is reflected back and forth. There's another of these instruments in Louisiana.

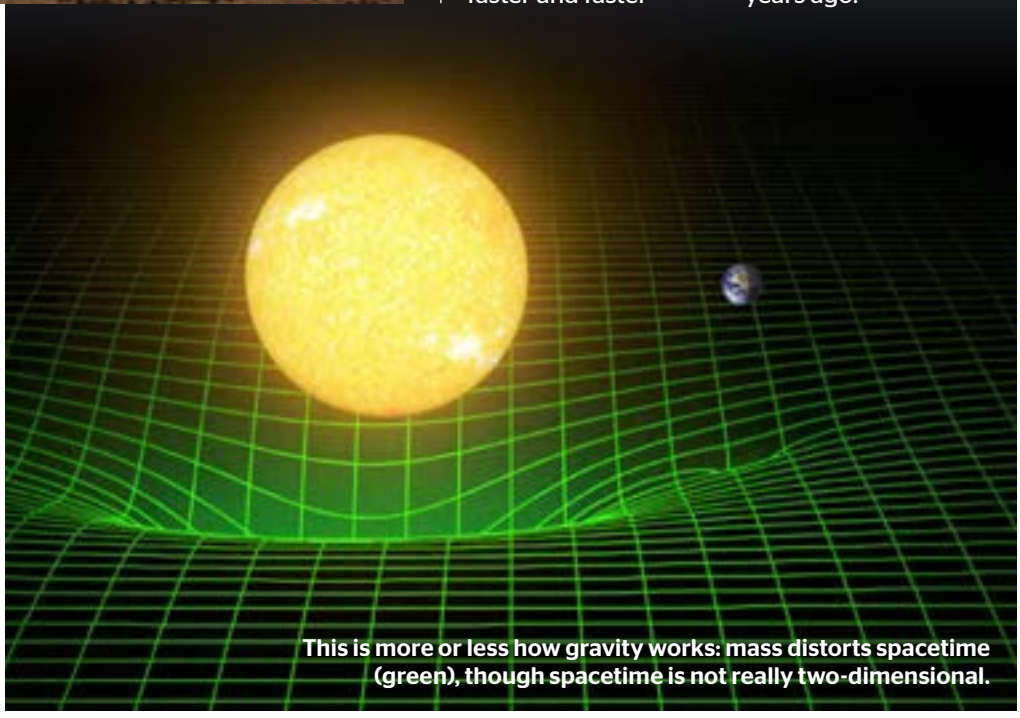
million kilometres. It consists of three satellites: the mother ship, which contains the detector, and two 'daughters', which reflect the laser signal. It should measure the space ripples of merging supermassive black holes in the middle of star systems. The plan is to launch LISA around 2034.

Science is not finished

The more measurements that are taken, the more we will learn about an unknown part of the universe and about physics. Can we expect another scientific upheaval in the near future? Nelemans doesn't think so. 'The first time we detected gravitational waves, after working towards that moment for thirty years, that was a really historical moment. That won't ever be replicated. But it does show that entirely new things can still be done, and that we Dutch are part of that process. It's really not as if science is finished.' □

How are gravitational waves created?

Einstein's theory of relativity argues that gravity is created when mass distorts spacetime. Imagine putting a very heavy ball on a trampoline. The trampoline sags. If you then put a lighter ball on the trampoline, it will roll towards the heavy ball. Exactly the same thing happens when a massive object in the universe distorts spacetime: it ensures that smaller objects are drawn towards it. But that doesn't mean you have gravitational waves yet. They are created when an extremely heavy object rapidly accelerates. When two black holes spiral faster and faster around each other, for example. A fluctuation is created in the curvature of spacetime, which spreads away from the source in the form of a wave. There are other objects that can cause gravitational waves. Other examples include neutron stars (stars that have become hugely massive at the end of their lives and spiral at a dizzying speed) with a small anomaly on the surface, as a result of which it emits waves as it revolves. Supernovas, gigantic exploding stars, also cause gravitational waves, just like the Big Bang, about 13.8 billion years ago.



This is more or less how gravity works: mass distorts spacetime (green), though spacetime is not really two-dimensional.

How do patients and doctors deal with breast amputation?

Breast strategies

How do breast cancer patients deal with their damaged bodies? Once surgeons are done with their operation that doesn't mean that patients have come to terms with their body. Philosopher Jenny Slatman studied this dichotomy. The appearance of a prosthesis receives more attention than how a women feels having this new body part. Is it even still part of her body?

Text: Margot Smolenaars

You're a woman and you have breast cancer. It's not unthinkable: it's a reality for one in nine women right now in the Netherlands. You're given the news and it blows you away. The oncologists' words still resonate in your mind. Cancer, survival odds, act now, amputation, reconstruction. The doctor shoves a bunch of treatments in front of you, choices and opportunities. He advises you about the best options. Once home, you stand naked in front of the mirror. There it is, the evil called cancer, in this one breast. Off with its head. It has to go.

After the operation (an amputation and reconstruction in one go because that was the most efficient solution, and convenient because the new breast is made from abdominal tissue, which makes your stomach flatter), you wake up in a hospital bed. You're in pain. You see your new breast for the first time when it's cleaned. That's hard to swallow. The redness of the scars seems to scream in your face. After a while they will fade, but then you make a peculiar discovery. There's hair on it. You've got pubic hair growing on your breast!

Coming clean

This could have come straight out of Roald Dahl, but this is the reality that philosopher Jenny Slatman, professor of medical humanities at Tilburg University, has been investigating. What happens with breast cancer patients when the treatment has ended, medically speaking, and they have to come to terms with their damaged and changed bodies? 'Many women expect the process to have ended once they have their new breast,' says Slatman. 'But that's actually when it all begins. Even after a successful operation, a women has to learn to come to terms with her new body.'

That's partly to do with how you deal with expectations, and that already starts with the terminology. 'The word "reconstruction",' says Slatman, 'creates an image that's not realistic, because it implies that a woman will be given back her old breast. That's never the case. You'll never be your old self, nor will your body.'

The English language has few words that cover the reality of the situation, according to the philosopher. 'It's not "mutilation", that word is far too negative. The same goes for "damaged". "Disfigurement" comes closest to what it's all about: the loss of shape.'

Abrupt break

Slatman began her research in 2011, after she had written her book *Vreemd lichaam* (Strange body). In this book she tackles physical identity and discusses subjects such as hand and face transplants and cosmetic surgery in TV programmes. 'I wanted to learn more about why appearance is so important. More specifically, what's the difference between having a body and being a body?'

The focus on breast cancer patients in her study entitled 'Physical integrity in disfigured bodies' is a logical outcome of that. Patients diagnosed with breast cancer experience an abrupt break with their healthy body and a healthy future. As a result, they start to see their body as a material thing that has to be fixed. Even though their body is no longer intact, patients may start experiencing it as their own again. The way that patients experience their body is the basis for the choices that they make during treatment.

Slatman also discovered that the gender aspect played an interesting role. 'An amazing number of women are treated for breast cancer. That means that many women have only one breast. But you never see them. Why do many women find one breast unacceptable?'

The answer has nothing to do with function. After all, a breast can't give milk anymore after reconstruction, and because there's barely any feeling left in it, the new breast also loses most of its sexual function too. 'So a reconstruction is largely aesthetic,' says Slatman. 'What's also striking is that breasts are reconstructed as faithfully as possibly, including a tattooed nipple. Prosthetics that are functional often don't resemble the body part that they're supposed to be ▷

According to Jenny Slatman's research, what women really want with a breast reconstruction is to forget the cancer.

‘What you see can be covered. But what you feel is there to stay’

▷ replacing. Think of the leg prostheses in *Bladerunner*.’

For patients, practical considerations play a major role in their choice for breast reconstruction. ‘Clothing doesn’t look good with one breast,’ says Slatman. ‘And many patients consider an external prosthesis in the bra a drag.’

Making better choices

What women really want when they have a breast reconstruction is to forget the cancer, or in any case leave it behind them. But that’s often easier said than done, because a post-cancer breast often feels different. ‘Sometimes you don’t notice it in a woman at all, because the scar is tiny. But she feels it, as a perpetually present and nagging, sometimes painful sensation. What’s worse? Seeing or feeling? What you see can be covered. But what you feel is there to stay.’

The fact that your body feels different after cancer bothers some patients more than others. ‘Silicone implants are stiff and don’t move easily. If a woman opts for implants, then she’s opting for a strange, foreign material, and so usually she won’t mind that she can always feel the shell there. It becomes more complicated with tissue produced by your own body.’ Because even if the new breast comes from a woman’s own back or abdomen, it never feels the same as the old one. Simply because the blood doesn’t circulate as well, which also means the new breast has a lower temperature than the rest of the body. On top of that, there’s hardly any feeling in it anymore.

The value of Slatman’s research lies in the fact that it offers improvement, from both a medical and a patient perspective. The recognition that the way in which a patient experiences her body affects her choice of treatment has led both patients and doctors to ask different questions. ‘Which incidentally doesn’t mean that doctors now refrain from doing it or that it’s always the task of the treating physician,’ Slatman emphasises. ‘The point is for the doctor and the patient to make a good shared decision.’

A breast cancer patient has a body but she also is that anatomy. How does she want to use her body after treatment? What activities are essential for her well-being? How important is the outside world to her? Does she run a lot? Is a décolleté important to her? What does she think of her breasts the way they are? How important is symmetry to her? ‘You’re then asking her things she’s probably never given much thought to, and yet they’re useful questions. They set a thinking process into motion, which will help her choose what she wants.’ □

Fighting cancer

Online blogs of women with cancer were analysed for the project. Women had four ways of telling their story. There’s the alienated patient who tries to understand what is happening to her and views her body and illness from a distance. The second group of patients ‘land’ in their bodies and start to see them as ‘theirs’ again. The disfigured woman tries to reclaim herself, even though the alienation is still present in the background. And finally there’s the heroic survivor, who identifies her cancer as an intruder that has to be slain. ‘This battle terminology comes from Richard Nixon, who declared war on cancer in 1971,’ says Slatman. In the initial years of her research she often visited women in their homes to interview them. It didn’t feel like entering an arena at all. ‘I entered the house of a sick person. The conversations were often emotional. Cancer is huge, and at the same time life goes on. At the individual level, in contrast to the experiences shared online, barely anyone uses this military terminology.’

How whole is it?

How ‘whole’ do patients with breast cancer still find their bodies after treatment? That was one of the main questions in Jenny Slatman’s study. A selection from the findings:

- Women only consider their breast ‘complete’ when the nipple has been reconstructed too.
- With the loss of feeling on the outside, a breast loses most of its sexual function after reconstruction. That’s largely because the new nipple is insensate.
- There is feeling on the inside, however: women who have had an implant are always aware of the silicone shell, which feels stiff and is less warm than the body.
- Patients experience reconstructions with tissue produced by their own body differently. Not all women with a breast made of their own abdominal or back tissue experience it as their ‘own’.
- Breast cancer patients undergo a process of alienation: they first have to distance themselves from their sick body before they can make their treated body their own again.
- Some women opt for amputation, even if an operation that spares the breast yields the same results. In rare cases, some women have both breasts removed, even if only one has cancer, in order to eliminate all risk. Fear is not always the motivation: some women opt to have both breasts removed for symmetry. Rather none than one.
- After an amputation, some women temporarily see their body as a foreign object that they need to get to know again. That’s not necessarily something negative, because it helps them to see their scars in perspective.

If you’re interested in learning more, visit mindthebody.eu

Dry maths?

Deserts don't fall from trees. They emerge. First the amount of rainfall declines, then fewer plants grow and eventually everything green disappears. That means: bye-bye arable land, bye-bye human habitat. This is a real risk for about 250 million people around the world. Once the last plant has kicked the bucket, it's hard to get anything to grow again. So we have to intervene at an earlier stage. Mathematician Eric Siero from Leiden University is offering help. He obtained his PhD with a model that calculates the process of desertification. 'The decline of plant growth happens in stages. First there's homogeneous growth, then plant growth in a striped pattern and after that the stripes start to break up. All that remains are isolated stripes or islands of green. And this is the crux of the matter: it's at that point that something really has to happen to fight desertification.' Siero's model takes grazing into account. Because in many areas, cattle eat up the scarce patches of green. If growth declines in one place, then farmers move their cattle to another spot. Subsequently the grazing pressure increases there, as does the risk of desertification. 'My model,' says Siero, 'calculates the consequences of grazing and provides tools for limiting it. It's always better for a farmer to let half of his sheep graze now than to have no sheep left at all in several years.'

MIHAI NETEA
professor of experimental internal medicine at Radboud University and Radboudumc.

Boosting our defences

We can boost the way that our body fights viruses and bacteria. Mihai Netea, professor of experimental internal medicine at Radboud University and Radboudumc in Nijmegen, wants to understand how our immune system fights pathogens and subsequently strengthen it. In 2016 Netea received an NWO Spinoza Prize worth 2.5 million euros.

Text: Elly Posthumus / Photography: Johannes Abeling

What does this prize mean to you?
'It gives me the opportunity to start working with some wilder ideas in the coming years. Sometimes you have a great idea that isn't so easy to put into words in a grant request. The Spinoza Prize provides an opportunity to work on these ideas and see whether they are true. This is going to open doors. It means we can do special things. It gives you freedom.'

Why is this freedom important?
'I think that there needs to be a balance in science between two kinds of research. On the one hand, the kind of research that has an immediate impact on society and visibly improves people's lives, and, on the other hand, research that gives you more freedom to discover new things, even though you are not exactly sure how they are going to affect lives. I think that the only way to do that is to let the entire scientific process take its course. Sometimes you come up with a notion but have no idea how to implement it. And then it turns out that someone from a completely different discipline can make good use of this discovery. Then it's suddenly very significant.'

Why do you think that you were awarded this prize?
'I think it's for the research that we are doing here on resistance to infections. We have conducted research in the past twenty years on the action of our innate and our adaptive immune system. The innate immune system is not specific, it attacks all infections. The adaptive or specific immune system attacks very specific intruders. You can actually compare non-specific and specific immune responses to doctors. A general practitioner has broad knowledge, but he can't solve everything. If you have a serious problem, then you need a specialist. Specialists don't have that broad knowledge, but they are extremely good at that one thing.

'In our immune system monocytes and lymphocytes are two types of white blood cells. Monocytes are immune cells of the innate, non-specific immune system and they attack everything. Lymphocytes are part of the specific immune system. During an infection they change and become highly specific. Then they can recognise pathogens that have infected us in the past. If the same bacteria or virus shows up a second time, they kill it very quickly. People therefore don't get sick and don't even realise that a bacteria or virus had them in its sights. The action of vaccines is based on this. We used to think that only lymphocytes could remember a previously acquired illness and respond to it more effectively the second time. But the cells of our non-specific immune system can do that too. And that, I think, has been one of our most significant discoveries.'

How did you discover that?
'One of the most important vaccines in the world is the BCG vaccine against tuberculosis. Young children in Africa and Asia, for example, are given it. It turns out that the vaccinated children are protected against more than just tuberculosis. They also have less chance of dying from other infections, such as blood poisoning or pneumonia, than non-vaccinated children. In the first year, the mortality of children who were given the vaccine was fifty to seventy per cent lower. Therefore this vaccine provides protection against other kinds of infections as well. This was already evident in the literature from sixty or seventy years ago. We asked ourselves: "How is this possible?" So we started searching for the answer.'

And so how is this possible?
'When you have an infection, your body produces proteins that are important for non-specific immunity. To produce these proteins, DNA is read by other proteins in cells, which are called ▷

‘There’s a continuous war going on between us and pathogens’

Who is Mihai Netea?

1968: born in the city Cluj-Napoca in Transylvania, the north-western region of Romania.
1993: Netea graduates in medicine from the Iuliu Hatieganu University of Medicine and Pharmacy in his city of birth.
1998: obtains his doctorate cum laude at Radboud University in Nijmegen.
1999: receives the Merck Irving S. Sigal Memorial Award from the American Academy of Microbiology.
2004: receives an NWO Vidi grant for research on how our immune system responds to the Candida fungus.
2005: after six years completes his training as a specialist in internal medicine.
2006: completes training in infectious diseases.
2006: that same year receives the W.R.O. Goslings Award from the Dutch Society for Infectious Diseases.
2007: becomes a specialist in infectious diseases at Radboudumc.
2008: Radboud University appoints Netea as professor of experimental internal medicine.
2008: becomes visiting professor at the Iuliu Hatieganu University of Medicine and Pharmacy Cluj-Napoca.
2009: NWO Vici grant for research on the immune system.
2011: wins the Radboud Science Award for researchers at the university who are responsible for the most exciting and important scientific breakthroughs of the year.
2013: receives the European Society for Clinical Investigation Award for ‘Translational Research’ for his clinical research.
2015: the European academy of the sciences grants Netea membership.
2016: becomes a member of the Royal Netherlands Academy of Arts and Sciences (KNAW).

▷ “transcription factors”. DNA is very neatly folded in cell nuclei. But during an infection, signals are transmitted that cause this DNA to loosen or open up. The transcription factors can then access it more easily so that the DNA can be easily read. Normally the DNA closes up quickly again when the infection leaves. But after some vaccinations, such as the BCG vaccine, it stays slightly loosely folded. When a new infection emerges, the proteins that are important for non-specific immunity can also be produced more easily and faster. And the faster you can produce them, the faster the cells of the non-specific immune system can kill the bacteria, fungi or viruses. The memory of specific immunity works for twenty or thirty years, or even your entire life. The memory of non-specific immunity lasts about half a year.’

Why isn’t the memory always turned on?
‘There are two issues here. There are infections that cause the DNA to close again. There’s a continuous war going on between us and pathogens. The pathogens have mechanisms that try to reverse the opening of the DNA. Second, I don’t think you would want your body to continuously trigger very high inflammatory processes in your body, because that could also have adverse effects. If the DNA is always open, that can lead to inflammatory and autoimmune diseases.’

When can you benefit from it?
‘It’s extremely important for people in certain risk groups. We can ensure that the immune systems of people who are at higher risk of getting infections, such as newborn children and the elderly, respond better temporarily. A child’s immune system is not fully developed yet in the first few months of life. If we turn on the process of opening the DNA, then it will protect children during that period. The classic vaccinations are much less effective in the elderly because their lymphocytes, the memory cells of the specific immune system, don’t work so well. We hope that this mechanism will enable us to find new ways of vaccinating the elderly.’

What fascinates you about our defence system?
‘When I was still a medical student, I read about interleukins, which had just been discovered. These proteins are our defence mechanism’s information system. They are like e-mails that our immune cells send to each other. The cells tell each other where there’s a problem and where more immune cells are needed to kill bacteria, for example. I found it so interesting that we stimulate people’s incredibly complex defence system with these proteins so that they can protect themselves better and we can offer them better treatment. But I am also fascinated by the history of mankind. When I had to decide what to study, it was a choice between history and medicine. But it was not a difficult choice. I lived in Romania before the fall of communism. History was used as propaganda at the time. So it was impossible to study history objectively at the time. But I have always retained my interest in history. I think it is fantastic to study things related to the evolution of human beings. That is why I also do genetic research on how different populations in Europe developed.’

That explains your research on Dracula’s descendants
‘Well, that’s what the press made of it. One of the open questions

in Romanian history is whether the first dynasty of Romanian kings were actually of Romanian descent. The warlord Dracula also belonged to this dynasty. The dynasty's family name was Basarab, but that's a Cuman name. The Cuman population came from Asia in about 900 AD and lived on Romanian territory for about 150 years. Was Basarab actually a Cuman, or was he a Romanian that got his name from beating the Cumans in battle? Because when that happened you often took on a surname that referred to it. The Roman general Scipio Africanus, for example, was not African, but that was his name because he had conquered North Africa. That could have been the case with Basarab I too. To find out, we analysed the DNA of forty living people from Romania with the same surname. It is easy to tell by sequencing the DNA whether it contains a piece of Asian origin. Their DNA turned out to be completely European. There was no trace of Asian DNA. The Basarab family therefore probably consisted of real Romanians, and so Dracula too was Romanian.'

Do you know what you're going to do with the money from the prize yet?

'I want to find out how we can use the memory of the non-specific immune system to develop new vaccines. We want to make people healthier. The elderly often acquire infections. It would be great if we could reduce that by 25 or 30 per cent. I would very much like to vaccinate elderly people with the BCG vaccine in a clinical trial. That has never been done before with that aim in a developed country, and it is definitely not dangerous. We dare to give it to newborn babies in the first hour of their lives. So we can certainly give it to older people too.

'I want what I do to have an impact on patients' lives. And on the way, I want to continue discovering things, about how our body works. What are the most important processes that protect us against infections? How did the immune system evolve? I find that extremely fascinating. During the course of history humans increasingly began to interact. Moreover, ten thousand years ago we started living with domesticated animals. As a result, the risk of infection is much higher than in the old times when you had a group of twenty hunters and gatherers running around in a forest. This elevated risk of infection has changed our immune system drastically since we discovered agriculture. And we have become stronger as a result of this interaction. If you look at which genes in our immune system have changed, then you know that these genes are important. If you could figure out the action of that gene, then you could also figure out ways of influencing it and treating a disease.'

Will we ever be able to make our immune system one hundred per cent effective?

'That does not exist. Although we can do our best to improve it, it is impossible to know everything about the action of the immune system. The immune system is always changing in evolution. That's what makes it so interesting. There are always new infections emerging, society is constantly changing, as are the interactions between humans and the nature around them, and with all that our immune system changes too. Imagine, it's impossible to happen, but imagine that you do come to know everything about the immune system at a certain point in time. That will only be the case today. But tomorrow everything will be different again.' □

What do the sex and love lives of adolescents look like?

Adolescent love and sex

You'd almost think, with all the reports in the newspapers about sexting scandals and young pimps who manipulate girls, that an adolescent's sex life is a minefield. A major study explored how youth view love, romantic relationships and sex.

Text: Anouk Broersma

Boys who watch a lot of porn have more liberal attitudes towards sex

'I broke up with my boyfriend, but actually we had pretty good sex. Now I long for sex every time I see a cute boy.' The first steps on the path to love can be confusing, as this excerpt from a sixteen-year-old girl's diary demonstrates. She was writing for Project STARS, which stands for 'Studies on Trajectories of Adolescent Relationships and Sexuality', a major national study in the Netherlands conducted by researchers from the University of Groningen and Utrecht University. For this study, 1,297 adolescents between the ages of 11 and 17 years participated. It aimed to shed light on their love and sex lives. How do they develop in terms of sexual activity? What factors play a role in this? And what do they think of love and sex?

The researchers used a variety of methods. They interviewed adolescents and their parents, had the former write in diaries, observed their behaviour on social media and asked them to fill in a longitudinal survey. All kinds of subjects were dealt with, including: personality, puberty, classroom popularity, self-image, their attitudes towards love and sex, sexual experience, the relationship with their parents and (sexual) online behaviour. The same group of adolescents were given the same list of questions four times with six-month intervals.

Adolescents who regularly talk to their parents about sex, think more about what they want in that area and when.

Informal talks help

A year and a half may not sound like a long period of time to monitor people, but the lives of adolescents can change fast. Take a question like 'Who or what teaches you the most about relationships and sexuality?' 'We see an enormous shift there,' says Daphne van de Bongardt, former researcher at Utrecht University. 'At the beginning many adolescents said it was their parents, whereas in last questionnaire, most of them said "peers".' Van de Bongardt also discovered that these peers play an important role when it comes to the timing of when adolescents start to have sex. Think of an adolescent who sees his or her peers already doing 'it' or peers that approve of having sex already. Chances are that he or she will also start to experiment. That's not an ideal situation, according to the researchers. 'Of course it's better if you do it because you want to do it, and not because of your friends,' says Van de Bongardt.

Just because friends are important doesn't mean that parents should be completely side-lined. In fact it's not a bad idea to have informal talks about sex from time to time. Project STARS showed that those adolescents who spoke to their parents about sex more often attached less value to what their friends were up to sexually. It didn't make them start having sex earlier or later, but these kinds of talks make adolescents think more about what they want, and when.

Porn for a more liberal attitude

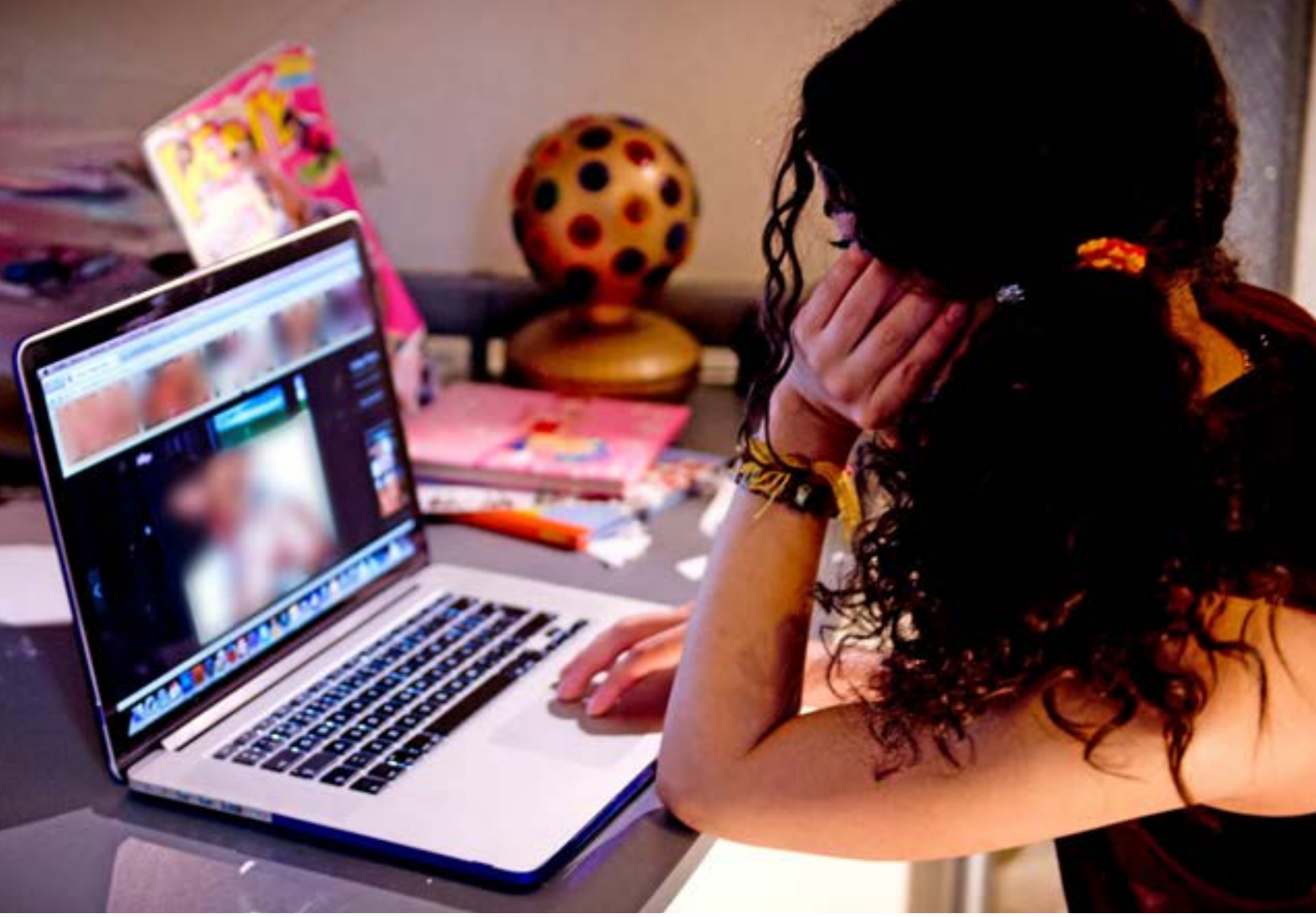
The most inexhaustible (and luckily anonymous) source to learn about sex is of course the internet. This doesn't mean, however, that curious adolescents are scouring the web en masse for porn, observed researcher Suzan Doornwaard (Utrecht University), whose focus in Project STARS was on the role of the internet in adolescents' developing sexuality. Only

A minority of adolescents watches porn. Boys do it more often than girls.

a minority of the participating adolescents said that they occasionally watched porn online, and these were especially boys. However, boys did progressively watch more porn in the one and a half years that they were monitored. The majority of girls said they never watch porn, both at the beginning and the end of the research period. How about cybersex or 'normal' educational sites about sex? Neither the girls nor the boys were very interested in them.

Of course the use of social media was

Who tells adolescents how to use a condom: their mother, their biology teacher or their friends?



also examined, though developments in that area are difficult to keep up with. For example, the now defunct social networking site Hyves was still part of the survey in 2013, whereas WhatsApp and Snapchat were not included yet. Sexting, the dissemination of sexually-oriented photos via smartphones wasn't a hot topic yet when the project was launched in 2010 and so didn't make it onto the list of questions. One thing was clear as day in any case, regardless of the kind of network or social activity adolescents were involved in: they invest a lot of time in social media, between 45 and 60 minutes a day. And the fact that Hyves has disappeared is unlikely to have changed anything.

These online activities can have an effect on daily life, as the findings demonstrated. Boys who watched a lot of porn had more sexual experience and a more liberal attitude to sex. For example, they found one-night stands or sexual relations with more than one person more acceptable. And the more they used social media, the more likely it was that both boys and girls were unsatisfied with their own sexual experience. Girls who hung around a lot on social networking sites were also more likely to think negatively about their body towards the end of the study.

Cliques

Boys whose voices are breaking, girls getting their period and growing breasts: Laura Baams, researcher for Project STARS from Utrecht University, discovered that those who experience physical change early are often the lovey-doveys of the class. Their popularity gives both boys and girls a romantic head start, but in different ways. The popular boys have sex earlier than their less popular peers. The popular girls don't necessarily have sex earlier, but they do manage to find a partner more quickly. How experienced adolescents are in terms of sexual activity can also determine their friendships. Emotionally unstable adolescents, for example, are more inclined to look for friends with the same sexual intentions. Whether that happens consciously or unconsciously is not clear, according to Baams. But previous studies have shown that emotionally unstable adolescents are shyer and more reserved about relationships. Perhaps they feel more at ease with peers who aren't such seducers either.

'It hurt'

Meanwhile, at the University of Groningen researcher Wieke Dalenberg asked about 300 adolescents between the ages of 12 and 17 years to keep diaries about their love lives, sometimes for two years. The result was a colourful collection of outpourings: from feelings about an ex-lover and daydreaming about making love with a classmate, to descriptions of the perfect lover (who ▷

It may be better for a peer to tell you what's fun and not fun in sex than a fifty-year-old biology teacher

often still needed to be found).
For the analysis of the findings, Dalenberg divided the stories in the diaries in different ways, for example into categories such as romantic and sexually-oriented subject matter. The stories in the first example were not about physical contact, but talked about falling in love and dating (or not). A seventeen-year-old boy, for example, confessed to a delicate dilemma: he was in love with four girls at the same time. 'I'm not sure what to do, because they're all good friends. I don't want to hurt them.'
The sexually-oriented entries were all about physical activities, such as kissing, cuddling and of course sex as well. Some, for example, wrote that they were having doubts about how far to go with their boyfriend or girlfriend. A fifteen-year-old girl divulged how she lost her virginity. 'I had hoped that it wouldn't hurt, but it did.'
Still, the vast majority of the stories in the diaries were purely romantic. Adolescents who were on cloud nine but had not had sex yet didn't seem too preoccupied with the subject. It could also be that they didn't dare to think about it 'out loud' yet. The adolescents who were sexually active already wrote about their bed secrets and insecurities, but they also continued to write about the rest: being in love, romantic dates or, of course, trouble in paradise.

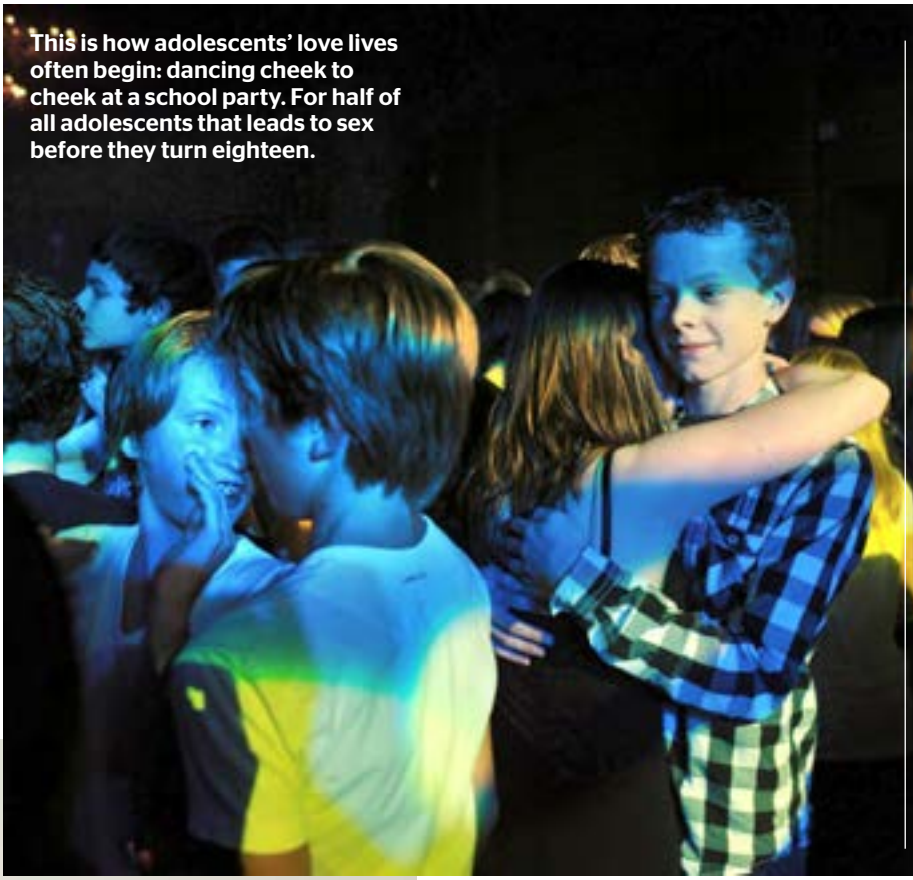
Previous studies of adolescent sex lives

Project STARS is the first study on youth sexuality in the Netherlands that monitored adolescents for a longer period of time, but it's not the first large-scale study on sex among teenagers. In the 1990s, for example, a number of health-care agencies ran a survey called 'Youth and Sex', and Rutgers and Soa Aids Netherlands conducted a study called 'Sex under the age of 25' in 2005, and again in 2012. Similar conclusions were drawn from these studies. The two 'Sex under the age of 25' surveys both revealed that about half of the questioned adolescents had had sex by the time they were 17 and that adolescents with a lower level of education generally start to have sex at an earlier age. Another conclusion, shared by Project STARS, is that sexuality is explored progressively. 'Most adolescents build their sexual experience step by step, from kissing to feeling and petting under clothes and fingering and jacking off to sexual intercourse.'

Young pimps, transactional sex

So not everything in adolescents' lives revolves around sex. On the contrary. And when they did have sex, the experiences were usually positive. 'There weren't many alarming cases, such as adolescents having sex for the first time at an extremely young age, negative experiences or cases of unsafe sex,' says Van de Bongardt. That didn't come as a big surprise to the researchers. 'We already know that adolescents in the Netherlands are relatively healthy when it comes to sex.' Certainly if you compare them to their peers in the United States or Great Britain, she adds. The prevalence rates of STIs and unwanted pregnancies among teenagers in those countries are four to ten times higher than in the Netherlands. Yet with some regularity there are shocking reports in the papers, for example about young pimps who manipulate vulnerable girls, transactional sex and sexting scandals. Are the media exaggerating these stories? Yes and no, according to Van de Bongardt: 'When the media claim that there's a "huge problem" in this area in the Netherlands among adolescents, then that's exaggerated. But of course there are small groups of adolescents here that do have risky sex or bad experiences. These are important issues to examine, but we didn't focus specifically on them in this project. Our main aim was to get an idea of "normal" sexual development.'

Dutch adolescents are sexually 'healthier' than their British and American peers, for example: they have fewer negative experiences with sex and have safer sex.



This is how adolescents' love lives often begin: dancing cheek to cheek at a school party. For half of all adolescents that leads to sex before they turn eighteen.

Acting tough

Conventional wisdom has it that women tend to talk down the number of bed partners they've had whereas men generally exaggerate it. Whether that's true or not, the fact is you can never know whether people are being 100% truthful about their sex and love lives. Don't adolescents brag a bit about their sexual experiences in order to act tough? Or hide things out of shame? 'You can never be certain with surveys, but we think that most of the adolescents who participated answered truthfully,' says researcher Daphne van de Bongardt. During the process of data collection, the researchers repeatedly emphasised how important honesty was for the study. And of course that it was confidential. That meant sitting far apart from one another, behind their computers, and no chit-chatting with classmates. The teenagers were also constantly reminded that they could stop whenever they pleased. 'So they didn't have to continue their participation if they felt it was getting too personal,' Van de Bongardt says. She's confident that they did think seriously about the questions. 'After all, it's an important subject for them.'

'How should I flirt?'

Parents and teachers don't have to worry excessively about the love lives of the average Dutch adolescent. Yet the emphasis in sex education still lies on the risks. A lot more could be done there, according to Van de Bongardt. 'In schools you often hear: "Look, here are some scary pictures of STIs. So don't have sex without a condom." There's much too little emphasis on adolescents' experiences, perceptions and relationships. They ask themselves questions such as: "What do I do if someone likes me? How should I flirt? How do I ask someone out? If I go up to someone's bedroom, what happens then?"'

Not all teachers will feel compelled to discuss these things in their classroom. Conversely, the kids in their classroom may find it just as awkward if their teacher does try. That's why Van de Bongardt thinks peer educators make sense. 'These are young educators who are peers or perhaps a little older so that they have some authority. They talk about their own experiences, what's fun and not fun about sex and how to establish boundaries. The COC (the Dutch organisation that advocates for lesbian women, gay men, bisexuals, and transgender people, ed.) uses peer educators to educate youth about sexual diversity. I think it would be extremely interesting to see whether that can be implemented more widely in sexuality education practices.' It may very well be effective; if only because young people are more likely to accept something from a peer than an (almost) fifty-year-old biology teacher. □

If you don't feel like putting your musings on social media, try the old-fashioned diary.

Why smokers' brains crave nicotine so strongly

Addicted to memories

Quitting smoking or drugs often works for a short time, but not permanently. Many people give in sooner or later. Memories play a major role when people relapse into addictive behaviour. Can we erase them or adapt them?

Text: Hidde Boersma

Joost (33) has been living in the west of Amsterdam with his girlfriend for a couple of years. He struggled with excessive cocaine consumption for years. He had a good job and lots of friends, but all too often his longing for drugs controlled his life. In the last three years that has decreased considerably, and now he only uses a few times a year. What's striking is that it keeps going wrong in the same way. He has a dinner or a party in the east part of the city, where he used to live. As he bikes past the places where he used to use and the houses where the dealers live, the urge to use resurfaces. And once he's had a few drinks, common sense goes out the window: he orders drugs again and doesn't come home till early in the morning.

Memories are key

Joost's experiences are precisely what Taco de Vries, neurobiologist at the VU University Amsterdam and the VU University Medical Center, focuses on in his work. He studies how addiction changes the brain. The big question is why people who try to quit relapse so often into their former habit. Memories appear to play a major role in this. 'Friends, spaces, attributes: when the brain recognises something,' says De Vries, 'then it retrieves all kinds of memories from there – memories that can have such a strong influence on the decision-making centre that there's no more holding back.'

De Vries' department focuses primarily on nicotine and alcohol addictions. Those are the only widely available, legal addictive substances, and paradoxically they cause the most problems. There are more than three million smokers in the Netherlands alone, and about 600,000 problem drinkers. Yet nicotine and alcohol were ignored for a long time: most research money worldwide went to cocaine (even though fewer people are addicted to it – about 30,000 to 40,000 in the Netherlands). According to De Vries this was a repercussion of the 'war on drugs' in the United States in the 1970s. Other Western countries soon followed suit. 'Illegal drugs had to and would perish from society. All the research money was used to make sure that would happen. As a result, neurobiology was tasked with understanding what happens when someone's addicted to cocaine, to find a way for them to kick the habit quickly.'

Nicotine more addictive than XTC

For neurobiologists, the boundary between legal and illegal substances is absurd. 'If you look at the brain, there's no basis whatsoever for the current division of what's freely available and what's only available underground. A recent English study identified alcohol as the drug that causes the most damage to society and the individual.' And nicotine is much more addictive than XTC or cocaine, and perhaps even more so than the much reviled heroin. 'Thirty per cent ▷

The memory of a drug deactivates rational thinking

▷ of people who light up a few cigarettes become addicted. That's an extreme number.' De Vries has attempted in recent years to find out exactly what happens in the brain when it becomes addicted, down to the smallest detail. 'An addictive substance is capable of striking at the heart of the brain's reward system, the *nucleus accumbens*, which is located deep in the brain, under the cerebral cortex,' De Vries explains. That area usually uses the brain to ensure that it feels good to continue doing the most important things in our lives. That mainly concerns food, drink and having sex, the basis of all life. Nicotine or cocaine are capable of adding themselves to that list of key activities. 'The brain thinks that smoking is just as essential to survival as eating. As a result the prefrontal cortex, our decision-making centre, is no longer able to suppress the urge to smoke.' Smoking becomes part of your normal behaviour pattern. 'We've even observed the prefrontal cortex of people who have been addicted to nicotine for a long time starting to shrink, which makes them lose control over their behaviour even more and live their lives based on impulses.'

Seventy per cent relapse

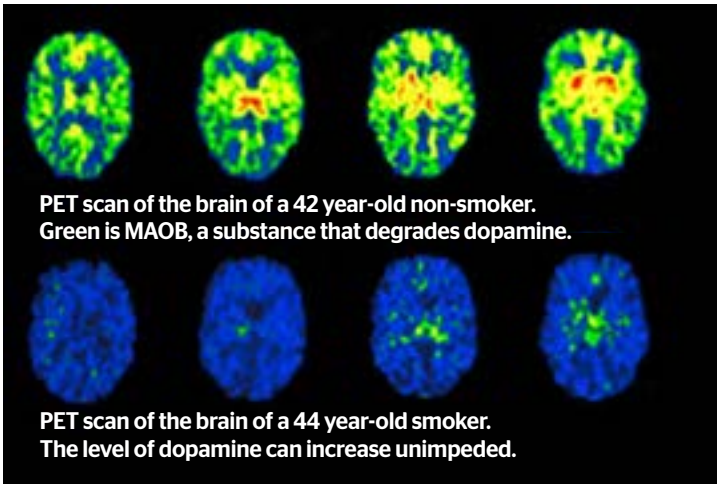
But the reward system doesn't conclusively explain why addiction is so persistent. The problem is reinforced by the fact that ex-addicts relapse quickly. Helping people to quit works quite well, but unfortunately it doesn't last very long. 'It depends on the drug, but usually more than seventy per cent of the people return to their old behaviour at a certain point,' De Vries says. 'It's not hard to stay off drugs when you're locked up in a clinic, but once you're back in your old neighbourhood, confronted by the same friends and habits, it's really difficult to keep it up.'

De Vries had a suspicion that memories played a role in all this. To examine it in more detail, he trained rats to associate an addictive substance with a sound or smell. After the rats were cured of their addiction, De Vries confronted them with one of the signals again. And indeed, before you knew it, the animals fell back into their old patterns.

Reason supressed

De Vries discovered that drug memories have quite an effect on the brain. Our brains are a network of cells that communicate by means of signalling substances. These substances, secreted by a cell, attach themselves to forklike receptors situated on the exterior of an adjacent cell. That's how signals are transmitted from cell to cell. If you retrieve a memory, then signals from multiple sets of cells converge, forming an entity and creating a memory in your head. But that's not all. 'We discovered that drug memories caused the number of receptors in the prefrontal cortex to decrease drastically,' says De Vries. That means that signals there don't get through as well. 'The prefrontal cortex normally helps us to make rational decisions. When the signal is weakened, then we start acting more on impulse. The memory of the drug therefore deactivates rational thinking, as a result of which the addict intuitively reaches for drugs again.'

These memories, which sometimes go back a long way, are stored in our long-term memory. Until recently scientists believed that it was impossible to deliberately introduce change there. Recent neuroscientific research has shown that memories can in fact be manipulated and



PET scan of the brain of a 42 year-old non-smoker. Green is MAOB, a substance that degrades dopamine.

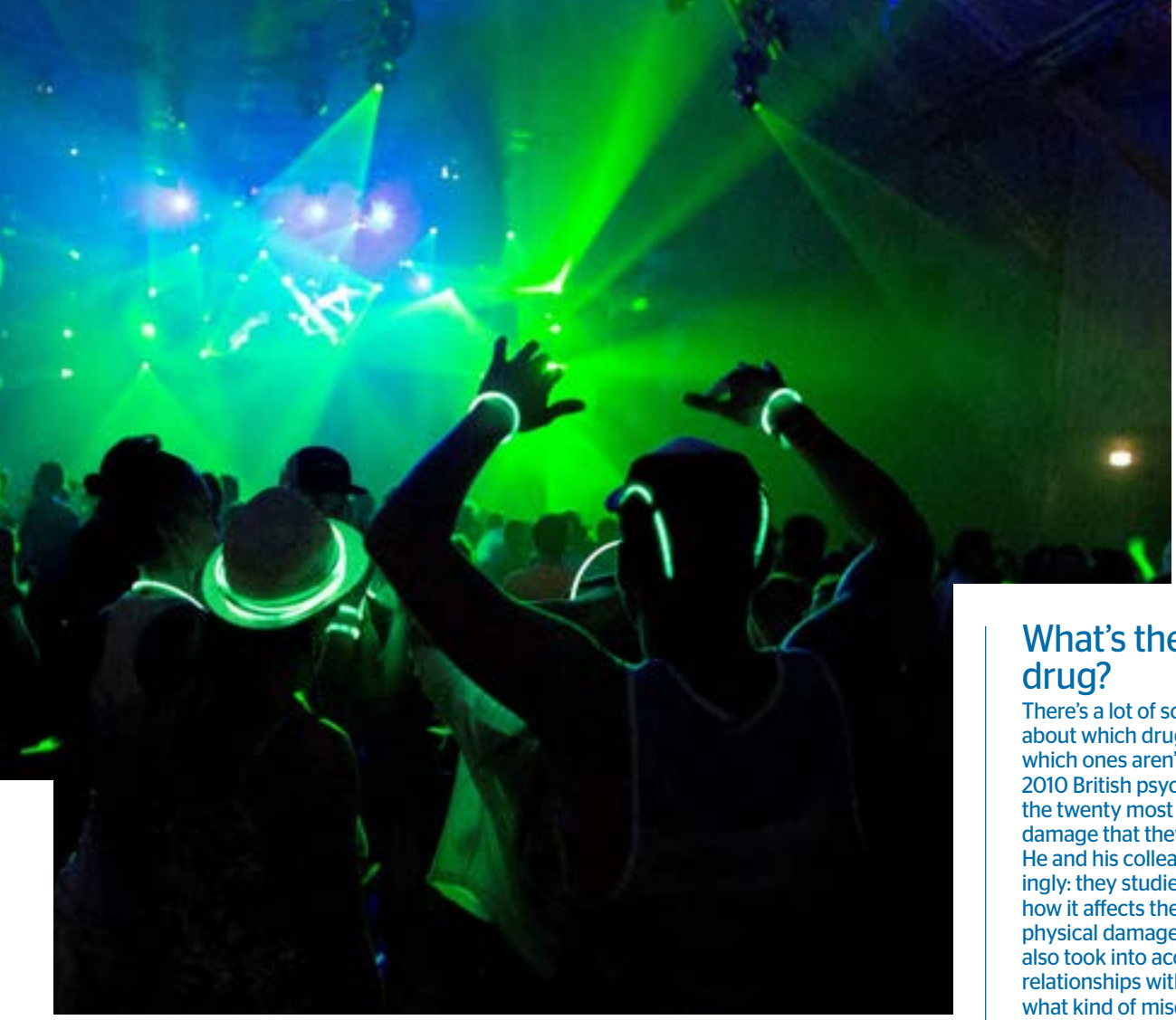
PET scan of the brain of a 44 year-old smoker. The level of dopamine can increase unimpeded.

Addictive substances create an excess of dopamine. Addicts lack the MAOB to degrade it.

Pills in all shapes, sizes and strengths are the latest trend.

Drug hypes

Drugs may be illegal, but they experience the same ups and downs as legal products. In the 1970s the hallucinogen LSD was the 'in' drug, whereas in the 1980s it was heroin, which caused huge problems in big cities. Now ecstasy is the most popular illegal substance: 3.1 per cent of men and 2 per cent of women have tried it. It is closely followed by amphetamines, cocaine and magic mushrooms. GHB and crystal meth are gaining in popularity. Research shows that drug markets function just like legal markets: dealers compete on price, quality and service. That has led to a higher concentration of the active substance in ecstasy pills, for example. While eighty milligrams of the active substance was the norm a few years ago, it has already doubled. These kinds of changes are difficult to control before using and sometimes cause problems as a result of overdoses.



Party drugs are somewhere at the bottom of the list of most harmful substances.

even erased. Memories are created because of changes that occur in certain neurons. Some genes are turned on, while others are switched off, as a result of which proteins are produced that strengthen communication with other neurons in a network, thereby recording memories. The new situation in the cell is 'hard wired', but not completely set in stone: as soon as somebody retrieves a memory, then for a short period of time it's labile and new proteins can be produced. After that the memory lodges itself firmly again. That process is referred to as reconsolidation. 'This labile stage lasts for about six hours,' De Vries says, 'and it seems as if it's possible to "rewrite" the memory during that time in order to weaken it.'

Erasing memory

One way of doing this is with the medication propranolol. It's used for anxiety disorders but also appears capable of partially altering the reconsolidation of your memory. It does so by blocking the signalling substances between the brain cells, which changes the way processes are carried out in the brain. How exactly is unclear. It works well with rats, but the results with actual patients still vary. Propranolol is probably not specific enough and may also block other processes in our brain.

That's why De Vries is trying to achieve the same results with behavioural therapies. One that others have considerable experience with is exposure therapy. So an addict, for example, will go back to where he used to use, without taking drugs this time. As a result, new memories are created that no longer associate that same place with drug use. Because the erasure and the reconsolidation of the old memory use the same mechanism, however, this therapy can backfire sometimes. Seeing these places again and again just makes the memory of drug use stronger. It's not possible to control that yet.

What works better, De Vries discovered, is to do intellectually demanding tasks during these six 'labile' hours. 'Puzzles or certain cognitive tasks seem to have an effect on the reconsolidation process.' Research on the impact of this in people has only just begun, but De Vries thinks that it will be possible to reduce the percentage of people who relapse. That would be great for Joost, who wouldn't have to worry about cycling to the east side of the city anymore. □

What's the most harmful drug?

There's a lot of scaremongering out there about which drugs are really harmful and which ones aren't. To settle the dispute, in 2010 British psychiatrist David Nutt studied the twenty most common drugs and the damage that they inflict on users and others. He and his colleague went about it painstakingly: they studied how addictive a drug was, how it affects the memory and what kind of physical damage the body incurs. But they also took into account how the drug affects relationships with friends and family and what kind of misery it causes internationally, such as the deaths that occur as a result of conflicts between Mexican drug cartels. The findings? Proudly topping the chart was alcohol, which causes immense damage to users and their environment. At a safe distance, with 25 per cent less combined damage, were heroin and crack, a specific kind of cocaine. All the way at the bottom were hallucinogenic drugs such as LSD and magic mushrooms, who end up just below ecstasy. They barely harm the environment and only harm users a little.

High-flyers in the world of science

Royal family businesses

Who? Jasper van der Steen (30), postdoctoral researcher of early modern European history at Humboldt University of Berlin. **Funding?** Rubicon: this programme enables recently graduated PhD scientists to gain experience at a top foreign institute.

What is your field of research?
'The Nassau dynasty in the period 1550 to 1750, specifically the Ottonian line from which our royal house descends. I study the princely dynasty as a family business. I want to know how the family members worked together to consolidate power over a long period of time. How did they prepare the next generation? And what role did women and the families of in-laws play? Historians often focus solely on the men, even though the family is extremely important when it comes to exercising princely power. If the head of the family died while his son was young or even unborn, the in-laws could play a major role in grooming the young prince.'

What does your time in Berlin mean for this research?
'Becoming acquainted with a different academic culture is a good experience. There's a weekly colloquium here in Germany where staff and students attend lectures and ask questions. Germany is also a country where many of the Nassaus lived, though I'm not closer to the archives here. My most important sources are in the state archive in Hessen. That's just as far from Berlin as Leiden is, where I first worked. The advantage of working here is that I'm expanding my network.'

Who will ultimately benefit from this research?
'I want to show historians that we need to concentrate more on the family to understand how Europe was run when political power was in the hands of princely dynasties. In addition, this research can serve as a source of inspiration for modern family businesses. They also need a good long-term vision. The notion that "I am a scion of this family" brings with it status, but also responsibility. Personal ambitions have to be set aside for family interests. These are the themes that matter in princely dynasties and family businesses.'

Jasper van der Steen: 'Historians often focus solely on the men, even though the family is extremely important when it comes to exercising power.'

Division gone awry

Who? Susanne Lens (47), professor of genetic instability, University Medical Center Utrecht. **Funding?** Aspasia grant (100,000 euros), linked to Vidi or Vici, in order to promote the advancement of more female researchers as senior lecturers or professors.

What kind of research do you do?
'I do fundamental research on cell division, a process that takes place throughout our lives in many bodily organs. A cell's hereditary material, packaged in the chromosomes, is duplicated during this process and neatly divided into two new daughter cells. But this division goes awry in about seventy per cent of all cancers. We're trying to understand the process of cell division at the molecular level by means of laboratory research, so we can grasp why cancer cells make errors in it more often. We're using the Vici grant to look at a specific protein complex that acts as a central machine in the dividing cell that turn sub-processes on and off. If you happen to inhibit that machine, then a great deal can go wrong during cell division. We're trying to find out which processes this mechanism controls and how that works.'

What inspired you to choose this field?
'My first source of inspiration was my biology teacher, who had a fabulous way of explaining how things worked in the human body. That's where my interest lay: I didn't want to make diagnoses, like in medicine. I wanted to know how things work and why they sometimes go wrong. During my studies and PhD there were always inspiring researchers as well, including intelligent women who conducted good research.'

How can you get more women to work in this field?
'Quite a few women work in it already, but the higher the level, the less women there are. I think this has to do with the persistent image that both men and women have of researchers as white, grey-haired men in lab coats. It would be good if there was a more active policy to profile female researchers, for example at conferences. When I tell organisers that there's only one female speaker in two days, they say "Oh, really?" I think it's pretty shocking that people aren't even aware of it.'

Susanne Lens: 'It would be good if there was a more active policy to profile female researchers, for example at conferences.'

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: Anouk Broersma / Photography: Johannes Abeling

Virtual aggression

Who? Bram Orobio de Castro (46), professor of developmental psychology, Utrecht University. **Funding?** 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 do research on children that become aggressively easily. To address that behaviour you need to practice with these children. We're using the Vici grant to launch a project to do this in VR: virtual reality. The child sees him or herself standing on a playground, for example. Other children on a school approach the child and one of them looks at the child too long. A typical scenario that makes some children blow their top. With VR we can program how long the other child looks and how. So with each child we can start at the level that he or she has difficulty with and gradually increase the intensity. We're monitoring two hundred children from the ages of eight to twelve. They all get the same therapy, and half of them also get VR training. After five years we're going to see whether it's possible to predict for which children VR therapy works and how.'

What inspired you to choose this field?
'A teacher in high school once said: "Actually it's important that people peacefully co-exist to some degree. Why is it that some people are so good at it while others seem to always be fighting?" That comment always stayed with me. I realised that if there's one thing that I really wanted to know, that was it.'

What do you think is the most important discovery in your field in recent years?
'When I was studying, psychology books and teachers said: some people are simply aggressive, there's nothing you can do about it. Nowadays we know that's not true, that you can achieve impressive results if you "help the children at an early age". There's not enough awareness of this discovery yet. In political circles you keep hearing about "youngsters who are bad apples" and that nothing will help, yet we are very aware of what we can do to help.'

Bram Orobio: 'Why is it that some can peacefully co-exist while others always seem to be fighting?'

Poisonous houses

Who? Ana María Ballesteros-Gómez (33), researcher of analytical chemistry, Institute for Environmental Studies, VU University Amsterdam. **Funding?** A Veni worth up to 250,000 euros that enables recently graduated PhD researchers to develop their research ideas.

What are you researching?
'I analyse consumer products, such as electrical appliances, furniture, textile products and building materials. They contain additives that are necessary for certain material properties. I'm referring to flame retardants, UV filters or plasticisers. The latter, for example, make a product flexible. Many of these substances end up in the air and dust in our houses and we inhale them every day. Some are poisonous. They increase the risk of cancer, for example, or they upset our hormonal system. I'm trying to track down these hazardous substances. I take samples by scraping material from TVs and other products. I also study household dust to discover how added substances move around the space. In the lab I analyse the samples for toxic additives with a new technique based on so-called ambient mass spectrometry. A few milligrams of material is enough and the analysis takes less than five minutes. You had to wait weeks sometimes before you had any results with the previous techniques.'

What do you think is the most important discovery in your field in recent years?
'Thanks to this new analysis technique, about thirty new added substances have been discovered in the last year and a half that are potentially poisonous and which are used a lot in daily products. Some of these discoveries have been published already, while other articles are being written as we speak.'

What inspired you to choose this field?
'The fact that enclosed areas, such as our houses and offices, are much less thoroughly studied than the outdoor environment, even though there's so much to discover. Consumers have the right and industry the duty to provide more information about the composition of their products. I want to contribute to that.'

Ana María Ballesteros-Gómez: 'Consumers have the right and industry the duty to provide more information about the composition of their products. I want to contribute to that.'

The wind was the spoiler for a balloon-borne mission above Antarctica

Better luck next time

A balloon flight above Antarctica was to be the acid test of a Dutch detector that can track down the ingredients of new stars. But for the mission to be launched, the weather needed to cooperate. And this time around it didn't.

Text: Frank Beijen

Do you want to know how stars and planets formed from dust and gas? Then you need to go to Antarctica. Better yet, forty kilometres above the icy continent. Instrument scientists Darren Hayton and Wouter Laauwen from SRON Netherlands Institute for Space flew to the South Pole region in November 2015. Their mission: prepare a measurement instrument for a NASA balloon-borne mission to capture infrared radiation from space. Its analysis will reveal the presence and properties of cold dust and gas clouds in the universe. Stars and planets form out of clouds of nitrogen, carbon and oxygen, but we're not yet sure under which conditions this takes place. The detector, a so-called hot electron bolometer that SRON developed with TU Delft, is capable of revealing invisible data about interstellar clouds.

Antarctica is the perfect place for a balloon-borne mission. Because the air is extremely dry, the detector will have barely any problems with vapour, which blocks infrared radiation in most places on Earth. The airship's solar panels absorb light 24 hours a day during Antarctic summers. And a cyclical wind blows above the continent every year in December. If you release a balloon then to a height of forty kilometres, this wind will blow it around the South Pole in two weeks' time and it will return to you like a boomerang. All you have to do is wait for the right wind.

Colder than Antarctica

To get the balloon into the atmosphere, Hayton and Laauwen first had to make preparations in the balloon hangar in Antarctica. They had to sync the detection equipment produced in the Netherlands with other instruments. To prevent heat from disturbing the measurements, they placed the detector in a kind of cold thermos flask filled with liquid helium. The temperature in this 'flask', which was 270 degrees below zero, was stone cold even by Antarctica's standards.

After almost two months of work came the 'suspension test': the gondola was suspended from a crane. The equipment worked flawlessly. The first part of the

The detector is in this gondola. This is the so-called 'suspension test'.

Testing the parachute (far right, by the vehicle), which should safely land the equipment undamaged onto Earth again after the experiment.

Gazing at interstellar dust

NASA's balloons provide a relatively inexpensive way of gazing into space. They don't use a penny's worth of rocket fuel and yet they station all kinds of measurement equipment as high as forty kilometres above sea level. At that height, more than 99.5 per cent of the earth's atmosphere is below you. There's barely any matter above there that can interfere with the measurements made by sensitive instruments. The aim of STO2, the mission that SRON scientists Darren Hayton and Wouter Laauwen were working on, was twofold. They were checking whether the detection technology would perform according to the requirements of space organisations NASA and ESA during a potential space mission. In addition, the researchers were measuring nitrogen, carbon and oxygen levels in the Milky Way. By determining their density and temperature, the researchers will learn more about the cycle of these substances. New stars are born from contracting gas and dust clouds. And as soon as a star reaches the very end of its life, it spews out new clouds of nitrogen, carbon and oxygen. To detect these clouds, STO2 captures infrared radiation. The receiver that SRON and TU Delft have developed is in a gondola full of instruments (such as sunshades and communication equipment). The gondola is suspended from a helium balloon the size of a football field.

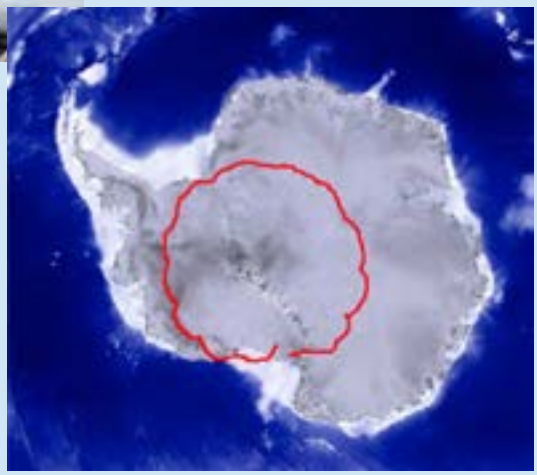
mission had succeeded. All that remained was for the balloon to take to the sky. But it soon became clear that the launch wouldn't take place in mid-December as planned because the weather phenomenon El Niño was disturbing the air currents in the atmosphere.
When would the launch be possible then? Every day at 11 AM the meteorologists at the McMurdo research station, where Hayton and Laauwen were staying, published their weather prediction. Sometimes there was zero chance of launching the balloon. But on other days there was a fifty to sixty per cent chance, and so the launch preparations had to be made.

The wind subsided

'From the ground, everything on Antarctica looks clear,' Laauwen says. 'The air is so dry that the airport seems to be ten kilometres closer than it is. You see mountains that are fifty to a hundred kilometres away. 'But that doesn't say much about the weather at higher altitude,' says Hayton. 'If there's even a little bit too much wind in the first 250 metres, or if the wind is coming from the wrong direction, then you can't launch. The balloon would be torn to shreds. You mustn't take a single risk with this kind of equipment.'
There wasn't a problem with the wind at great altitude. If the balloon had been able to reach that point, then it could have easily circled the continent. But the weather conditions in the lower layers of air were not good enough. By the time the cyclical wind died down after a few weeks, the balloon had never even made it out of the hangar. 'For the first time in twenty years, a NASA balloon-borne mission was cancelled. It's simply bad luck that it happened to be our mission,' says Hayton. 'Technically speaking everything went well. But as a scientist you're not always in control of everything. We depended on the weather, so we knew there would always be a chance of things going wrong.'

There will be another opportunity

The SRON researchers don't look back at this period as a frustrating one. And luckily they didn't face the same trouble that another balloon-borne mission faced that was being prepared in the same hangar at the same time. That balloon was meant to conduct research on solar flares. It was launched, but it crashed after eleven days in a remote area of Antarctica. The equipment will be retrieved later this year. 'It's better to not fly at all than to fly for just a few days,' Hayton says. In late 2016 Hayton will go to Antarctica again to supervise a new attempt. 'I think that we'll succeed this year,' Laauwen says. 'Everything is in place.' But as Hayton says, 'there are never any guarantees'. □



STO1, STO2's predecessor, floated along this route in 2012.

Sometimes you need large-scale facilities to make major discoveries

Major research

You need major databases, powerful computers and enormous telescopes to do research with large amounts of data. NWO is helping science with the necessary infrastructure.

Text: Adriaan ter Braack

NWO is investing in large-scale research facilities

Good research facilities are indispensable for top-flight research. Think of telescopes, ICT facilities and data collections. That's why NWO is providing long-term funding for these facilities. Every two years, eighty million euros goes to large-scale research facilities, scientists can reserve time on the LISA and Cartesius supercomputers, and NWO provides access to research facilities abroad. As a result, Dutch scientists can conduct research using the Isaac Newton Group of Telescopes on the island of La Palma. Finally, NWO ensures that the facilities at all NWO research institutes are accessible to researchers here and abroad. An overview of all large-scale facilities is available at www.onderzoeksfaciliteiten.nl. Scientists can use this website to find out which equipment and databases they can use for their research. The site should also promote cooperation in the development of new facilities.

Twelve countries are participating in the SKA telescope. It will be built between 2018 and 2020.

Biobank network

WHAT? BBMRI-NL (Biobanking and BioMolecular Resources Research Infrastructure The Netherlands), a partnership between Dutch biobanks with collections of medical data and individuals' biomaterial.
WHAT CAN YOU DO WITH IT? 'Diseases that we used to group together, such as cancer, diabetes and cardiovascular disease, turn out to consist of different biological sub-types', says scientific co-director Gerrit Meijer.
'In order to study these properly, backed up with enough statistics, we need a constantly growing large collection of data, samples and images of healthy citizens and patients. That's why we work with biobanks both here and abroad, whereby BBMRI-NL represents the Dutch biomedical data, sample and image collection. It's important in health care that prevention and treatment are as customised as possible. Population-based biobanks, in which people are monitored in times of good health and illness over a longer period, are crucial to a customised approach. Combining different kinds of data makes it easier to recognise a subtype of a particular disease at an early stage, for example.'
HAS IT ALREADY GENERATED NEW INSIGHTS? 'BBMRI-NL has already completed a number of successful

Giant radio telescope

WHAT? SKA (Square Kilometre Array), a radio telescope consisting of 200 dish antennas in South Africa and 130,000 dipole antennas in Australia which are connected via a fast network of fibre optic links to a large supercomputer. Together the collecting area of the antennas and dishes approaches one square kilometre.
WHAT CAN YOU DO WITH IT? 'SKA is much more sensitive than other radio telescopes, so we can detect weaker signals and therefore look back further in time,' says Michiel van Haarlem, head of SKA NL. 'We hope that will enable us to get a better picture of the formation of the first stars and galaxies. That, in turn, should lead to a better understanding of the fundamental laws of physics. By studying pulsars, which are remnants of a star after a supernova explosion, we can put Einstein's general theory of relativity to the test.'
WHAT IS IMPORTANT IN SUCH A PROJECT? 'The scope and cost of SKA are considerable, so international cooperation is extremely important. We're trying to set up an international treaty organisation that will have the task of building and running the telescope. Moreover, the extreme sensitivity of SKA is only possible thanks to the development of new technologies, such as sensitive antennas, fast, energy-efficient computers and intelligent new algorithms that process and visualise the data. The amount and complexity of data that SKA will generate is the reason why there are plans to set up a Science Data Centre in the Netherlands. That will give users access to the telescope and archived observation data.'

projects, such as Genome of the Netherlands. That project unravelled the complete DNA sequences of 750 Dutch people. This data collection is used frequently in clinics and for research. Now that the unravelling of DNA is playing an increasingly important role in the diagnosis of diseases as well, it's important to know what's "normal". The Genome of the Netherlands is an important reference for that.'

Genetic material is kept in these kinds of tubes.

The supercomputer simulates research that's too expensive or dangerous

All Dutch universities and a number of scientific institutes can use the calculating wizard Cartesius.

Proteins at work

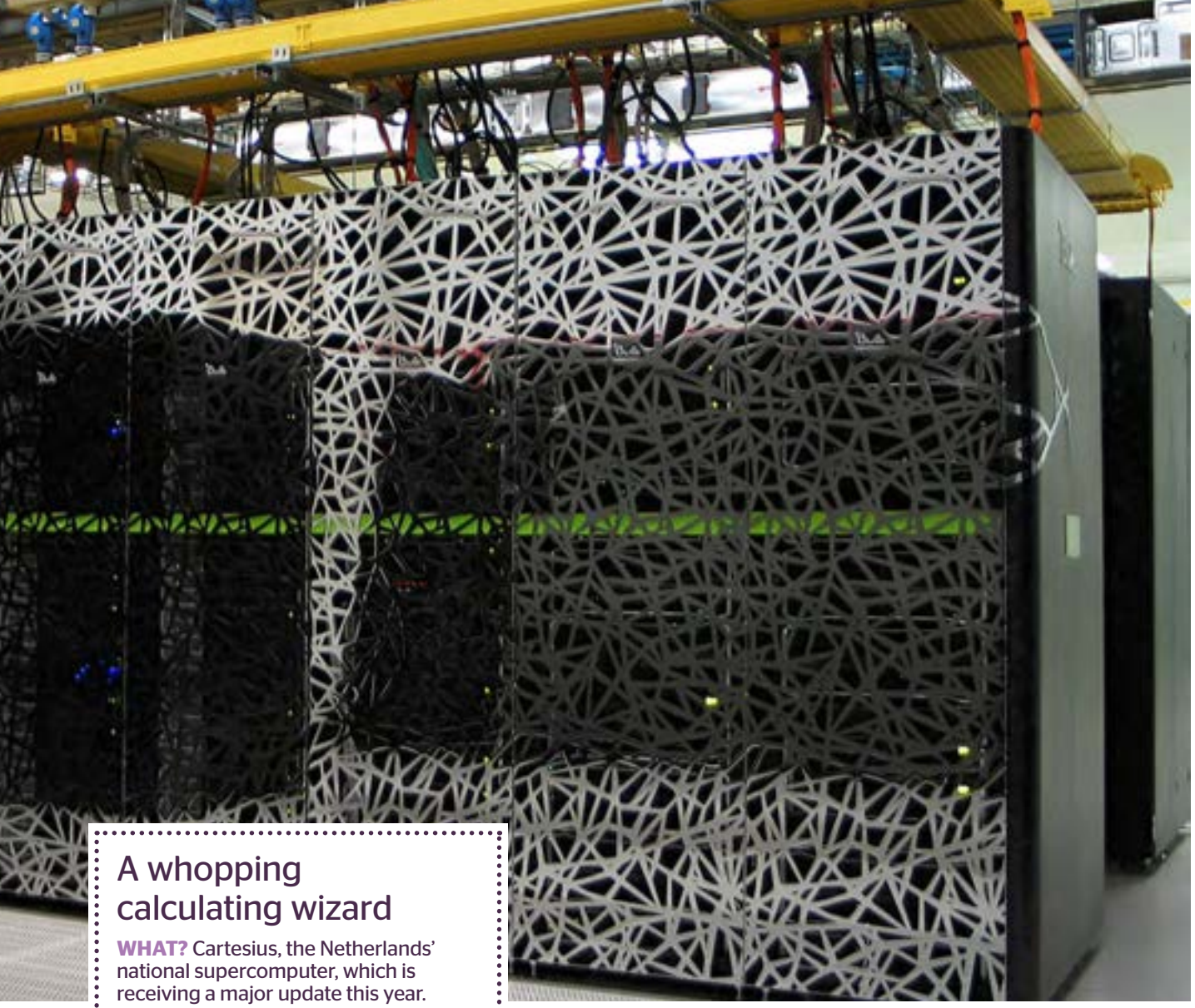
WHAT? Proteins@Work, a research facility for proteomics, the study of the biological function of proteins in cells. The facility provides access to techniques, equipment and expertise for biology and biomedical researchers.
WHAT CAN YOU DO WITH IT? 'Proteins are produced by genes, which are encoded in the DNA,' says Albert Heck, scientific director of the Netherlands Proteomics Centre. 'The specific composition of proteins determines whether a cell – such as a skin cell, muscle cell or brain cell – works. By studying these proteins, and interaction, we can gain a better understanding of how life works, and that's important for medical and biological research. It enables us to determine the cause of diseases, for example, so we can develop new therapies.'
WHAT'S PROTEINS@WORK ALL ABOUT? 'You can study proteins by measuring their unique fingerprint in cell or tissue samples. Mass spectrometry enables us to determine the identity, and indirectly the function, of proteins,' Heck explains. 'We do this with tens of thousands of proteins in a single experiment. We create about one million fragments from that, which are then analysed by powerful mass spectrometers and computers. These techniques require a great deal of expertise and investment in hardware and software.'
WHAT CAN YOU DO WITH THIS KNOWLEDGE? 'Proteomics enables you to answer a lot of questions. How much of a certain protein is present, or how do proteins work together in a cell? Which proteins are typical of a certain function or disease? We already know how to reprogramme skin cells into a stem cell. Essentially this means reprogramming all proteins present in a cell. Scientists can now give cells new and specific commands. For example, a command to repair tissue or a damaged organ. That's already happening in laboratories, with cells in laboratory animals, but not in real patients yet.'

Treasure collection

WHAT? PAN (Portable Antiquities of the Netherlands), an online database of private metal detector finds, so that they become available for scientific archaeological research.
WHAT CAN YOU DO WITH IT? 'An enormous amount of archaeological objects have been collected from Dutch soil in recent decades by amateur archaeologists with metal detectors,' says Nico Roymans, professor of archaeology at VU University Amsterdam. 'It concerns thousands of collections that have never been systematically inventoried, but which, taken together, are of unique scientific value for the history of the Netherlands. A database ensures that this data is not lost.'
HOW IS PAN BEING DEVELOPED? 'A variety of aspects are important to set up this infrastructure, such as a good network of metal detectors in the Netherlands and a digital database that is accessible to both scientists and the general public. We also need a team of archaeologists to make an inventory in the coming years of all the collections in the Netherlands. For the sake of continuity, the database will ultimately be handed on to the Cultural Heritage Agency following the project period.'

Archaeological finds by amateurs can also be valuable to science.

WHAT KIND OF ISSUES CAN PAN HELP TO SOLVE? 'The data can be used for a broad range of archaeological and historical issues – for example, to determine the population density of regions, inter-regional commercial ties, the functioning of market economies and migrations. The database can also be used to determine whether a site is interesting, archaeologically speaking, so that it can be handled in an adequate manner. Battlefields, for example, can be identified by the concentration of fragments of military equipment and musket balls.'



A whopping calculating wizard

WHAT? Cartesius, the Netherlands' national supercomputer, which is receiving a major update this year.
WHAT CAN YOU DO WITH IT? 'Supercomputers are used for large-scale technical-scientific calculations,' says Chantal Cassee, head of communications. 'It usually concerns simulations of research that would normally be impossible, too expensive, too dangerous or too extensive.'
IN WHOSE INTEREST IS IT? 'From chemists who want to calculate the structures and interactions of molecules to climate scientists who test models. Other uses include calculating currents around ship propellers, airplane wings and currents in blood vessels and rivers. Supercomputers can make faster, more sophisticated calculations of all these processes.'
IS IT NECESSARY TO UPDATE A SUPERCOMPUTER? 'Supercomputers become outdated as quickly as regular PCs. In other words, what's a supercomputer today will already be so outdated in five years that it needs replacing. By that time you can get a machine that's ten times as fast for the same price,' says Cassee. 'The gain in speed used to come from faster processors, but today it comes from a greater number of processors.'

Humanities databank

WHAT? CLARIAH (Common Lab Research Infrastructure for the Arts and Humanities), an infrastructure that brings together data and software from the humanities and makes it accessible.
WHAT CAN YOU DO WITH IT? 'Large amounts of data in the form of text, images, structured information and audiovisual files will soon be available digitally,' says Patricia Alkhoven, coordinator of external cooperation. 'These data make it possible to conduct innovative research in the humanities, providing they are stored according to internationally recognised standards. Then all digital sources can be linked to each other, creating a gigantic collection of data.'
WHAT DOES ITS DEVELOPMENT ENTAIL? 'The effectiveness of the database relies completely on the availability of standards that everyone can use in their work, the possibility of continuing to work with old and trusted software and the willingness of researchers to share their data with others. We can develop fantastic programs, but if not a single humanities researcher sees its use, then the infrastructure will become an amazing four-lane highway that nobody drives on.'
WHAT CAN YOU RESEARCH WITH CLARIAH? 'Examples? How do classic media (newspapers, magazines, radio and TV) interact with new social media, such as Twitter, Facebook and blogs? Or why have some regions in the world been wealthy for so long and others poor? How is our language changing under the influence of new media?'

Bad neighbourhood or bad street corner?

From neighbourhood to street

Authorities often focus on problematic neighbourhoods to fight crime. But a street-oriented approach is possibly more effective, according to recent research.

Text: Pepijn van der Gulden

A bad neighbourhood, what do you mean by that? Crime doesn't limit itself to the borders of a neighbourhood. Many individual streets in 'bad' neighbourhoods are trouble-free. And parts of certain streets in 'good' neighbourhoods stand out because of the frequent crimes being committed there. So it makes more sense to talk about 'problematic parts of streets' than problematic neighbourhoods. This was the finding of a 2015 study conducted by criminologist Wouter Steenbeek from the Netherlands Institute for the Study of Crime and Law Enforcement (NSCR) in Amsterdam. Focusing on the street creates opportunities to improve our understanding of crime, and it may be a more effective way of fighting crime than an approach that focuses on larger areas.

Know what you measure

Science tell us that to measure is to know. But measuring isn't always that simple, as Steenbeek has frequently discovered. As a criminologist he investigates areas with

Follow-up research

Crime differs from street corner to street corner. How can these differences be explained? Wouter Steenbeek from the NSCR is focusing on this question in his follow-up research. He will be examining why more crimes are committed near cafés and shops. Cafés probably choose to establish themselves in central locations where there's also more crime. Steenbeek will also examine the impact that businesses have on their surroundings by comparing crime figures before and after a business was started in a given street. Steenbeek will try a similar strategy by investigating the opening and closing times of businesses. A considerable number of crimes are committed at The Hague Market, for example, which may be related to the crowds of people that converge there. If there's a lot of crime outside opening hours too, then the crowds can't be the only explanation.

A pickpocket is handcuffed in Volendam.

The police begin their investigation in a street in Hilversum after a man was found wounded there.

high concentrations of crime. Not surprisingly there is more crime in large urban areas than in rural villages, and more crime in shabby, run-down areas than in fancy neighbourhoods. It's for good reason that criminologists have spent so much time focusing on the differences between neighbourhoods.

But how big are these differences? Perhaps there's more trouble in one street than another. There may even be differences within a single street. Indeed, Steenbeek realised that these street segments may well be a more useful unit than neighbourhoods. 'A street segment is the piece of road that goes from one intersection to another. Intersections and side streets are a natural boundary. I keep an eye on my neighbours and they do the same for me. Anything further than that is pretty much where my world ends.' While street segments are fairly homogenous, there are large contrasts in neighbourhoods in terms of busyness and types of inhabitant. The difference in crime figures should be noticeable at the level of street segments, argued Steenbeek. 'We noticed that in American research as well, where they're a step further than us with these kinds of studies.'

But this kind of research wasn't so easy to conduct in the Netherlands. Crime figures at the street segment level are more difficult to obtain than in the US, where citizens can easily access accurate crime figures on the internet. Thanks to a partnership agreement between the NSCR and the police in The Hague, Steenbeek was able to access the coordinates of all offences known to the police in the period 2001–2009, varying from fights to burglaries and theft. This enabled him to determine in which street segment each offence had been committed. What was also useful for his research: he could compare to what extent crime varies at the district, neighbourhood and street segment level, because each street segment is in a neighbourhood, and that, in turn, is part of a district.

'Bad' piece of street

The findings were surprising. Although a ▷

There's never any crime in some street segments The Hague

lot of research and interventions focuses on districts and neighbourhoods, street segments may play an important role. There are major differences between street segments, Steenbeek discovered. 'Three-quarters of the crimes committed in 2001 took place in only seventeen per cent of the street segments.' A small part of the street segments in The Hague therefore was burdened with the lion's share of criminality. More violence and theft occurred there, as well as more burglaries, while other street segments had remained crime-free for years. 'In each separate year, about half of the street segments experienced no crime, and over the entire nine-year period there was even no crime whatsoever in about twenty per cent of all street segments,' Steenbeek says.

He also discovered major differences between districts (i.e., relatively large areas, consisting of multiple neighbourhoods). Some districts had relatively many 'criminal street segments', which made them stick out from the rest. 'There's a clear concentration: if you visit a quarter of all districts in The Hague, then you'll have stumbled across about two-thirds of the city's crime.' But the differences between street segments appear to be greater than those between districts. There are streets in the same district where nothing happened for years. Conversely, there are relatively quiet districts where some street segments are burdened with a great deal of crime. The difference between one street corner and the next can be considerable. 'As a simple example: the segments around the boulevard in Scheveningen clearly stand out. If you turn a corner there, there's already much less crime. And yet another corner further and you'll find there have barely been any incidents through the years. But a little bit farther away, you'll again find a street segment where crime occurred consistently over the years.'

Is busyness the key?

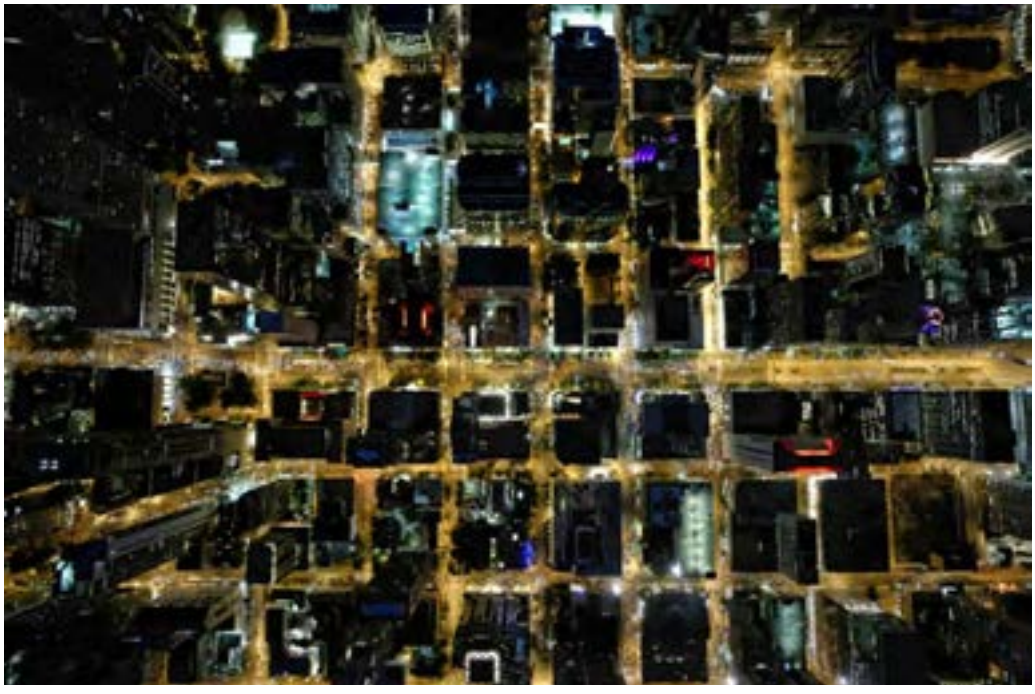
The next step seems to be to explain why crime differs from one street corner to the next. Steenbeek hasn't reached that point yet. 'I first focused on determining the differences.' To explain them, he is now concentrating on the importance of busyness. What struck him about the raw data was that busy places such as The Hague Market and the boulevard have to contend with a lot of crime, which is in line with criminological theories. 'Many people gather there, and crime can only take place when a determined perpetrator and a suitable target converge in one place.'

It's still unclear under what conditions that does or does not lead to a crime being committed. Moreover, explaining that at the street corner level is difficult, because detailed data about potential explanations, such as the presence of people at different times of the day, is usually not available. Steenbeek already has a potential solution in mind. 'The structure of the street network indicates how many people use that street. For example, people can easily get to the shopping street via the street section where I live. That's why many more people walk there than the street behind it.' By modelling the street plan, Steenbeek hopes to come closer to finding an explanation (see box, 'Follow-up research').

More than crime

Still, Steenbeek believes that the findings could already be useful for policymakers. 'What you see is that certain street segments experience many problems, whereas a neighbouring street may not be bothered by them at all.' Neighbour-

Chicago from above. Crime is usually mapped by block and not by street segment in the US.



Blauwvoetstraat in the Kolenkit district had the dubious honour of being the street with the most burglaries in Amsterdam in 2014.

hood watches seem a fairly crude way of fighting crime. A more targeted approach makes more sense, in light of the fact that half of all crimes were committed in only seven per cent of the most problematic street segments in The Hague.

But Steenbeek is reluctant to completely dismiss a neighbourhood-oriented approach. 'A policy that focuses on neighbourhoods is often about more than just crime.' Criminality may be concentrated in a few streets, but problematic neighbourhoods also frequently struggle with poverty, unemployment and overdue maintenance. So a focus on neighbourhoods makes more sense for those kinds of problems. In practice, the accuracy of the street segment level can be tricky. Future policy would have to focus on hundreds of segments, which are spread across the entire city.

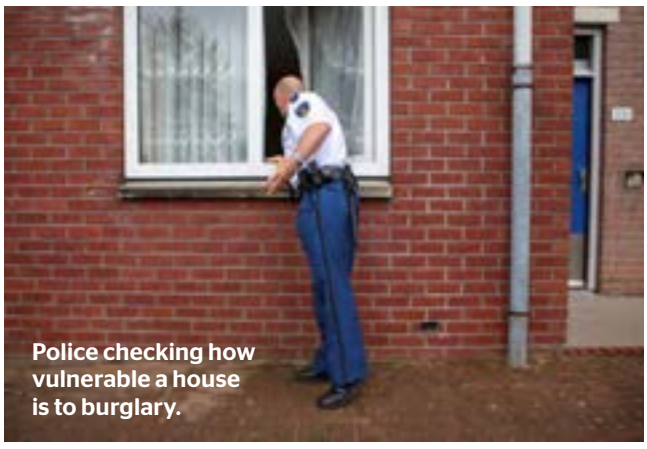
Indeed, that's why the criminologist doesn't venture to offer sweeping policy recommendations. 'My mandate,' Steenbeek says, 'is primarily to find out how the world works.'

Back to Chicago

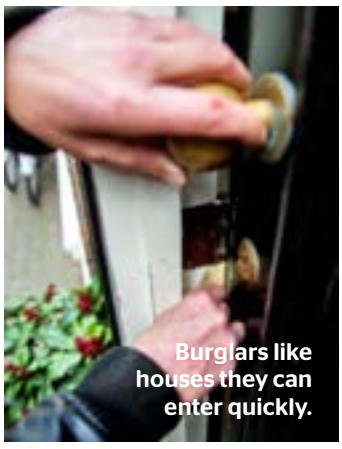
Steenbeek's research is an important step in that direction. It turned out to be so innovative that American criminologists recently replicated it in Chicago. Because even though Steenbeek was inspired by research from the US, he introduced a key innovation. 'One major disadvantage of the American data is that the smallest spatial denominator there is often not the street segment but the block.' A block is the smallest area surrounded by (usually four) streets. But major differences can exist between its corners. The street segment, on the other hand, seems to be a more convincing unit of measurement, as has been confirmed in the research replicated in the US. The American criminologists copied Steenbeek's study table by table. Steenbeek is particularly flattered that they chose Chicago, because the 'Chicago school' of criminology from a century ago played a crucial role in developing scientific research based on the influence of neighbourhoods on crime. 'Chicago is the benchmark for neighbourhood research in criminology. It's fantastic to see that my research is being replicated there, with very similar results.' □

Hit the streets with Google

What makes some houses more appealing for burglary than others? Are they out of sight? Do they have many windows on the ground floor, a tall hedge or can you see the TV from the street? Sam Langton, one of Wouter Steenbeek's master students (now pursuing a PhD at Manchester Metropolitan University), examined this question from his lazy chair, using Google Street View. He compared the surroundings of 200 houses that had been burgled with 200 that hadn't. In addition to saving time, Street View also provided a scientific benefit. The slightly dated pictures showed houses before they had been burgled. That's important, because after a burglary the residents may have trimmed the hedge or built a fence. What did Langton find? Burglars look for houses that are easy to enter, but more importantly ones that they can flee from quickly too. Detached houses with multiple escape routes are popular, while a clearly visible front door is a deterrent. Funnily enough, it doesn't seem to make any difference whether a house appears wealthy, with potentially lucrative spoils.



Police checking how vulnerable a house is to burglary.



Burglars like houses they can enter quickly.

IN BRIEF

A classic window to the future

Solar panels are indispensable for a future full of sustainable energy. The problem is that you can't see through them, and so they can't be incorporated into windows. As a result, much of the space in a façade is lost. Wilfried van Sark from Utrecht University developed a transparent, energy-generating version of a Mondriaan painting. 'The coloured panels,' Van Sark says, 'contain a pigment that captures sunlight and emits it in one particular colour. There are solar cells in the sides of the panels that capture light and convert it into electrical energy.' The yield is less than in a normal solar panel, but they can be used as windows. 'I'm working towards a future in which we can cover entire façades with these coloured elements. That will really make a difference!'

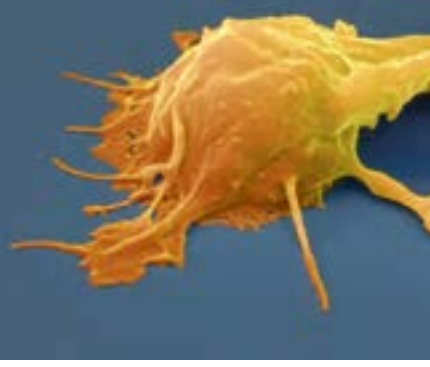
On a sunny day, this 'electric Mondriaan window' generates enough energy to load three mobile phones.

Marsdiep sets warmth record

Marsdiep is situated between Den Helder and Texel, where the Royal Netherlands Institute of Sea Research (NIOZ) has been measuring the seawater temperature since 1860. With an annual average temperature of 12.8 degrees Celsius, 2014 was the warmest year on record. Nonetheless, Janine Nauw, physical oceanographer at NIOZ, was not surprised. 'The atmosphere that year was also the warmest ever recorded, and the water temperature usually adapts to that pretty quickly.' The NIOZ now measures continuously and uses electronic sensors instead of doing it once a day manually. 'That's generating useful data about the Wadden Sea,' says Nauw. 'For example, the Wadden is colder than the North Sea in winter, whereas it is warmer in summer. The reason for this is that it is shallower and therefore warms up and cools down faster."

Natural killers safe after all

A potential new therapy for leukaemia patients has been developed at Radboudumc. Researcher Harry Dolstra explains: 'The project started by growing stem cells from umbilical cord blood into NK cells, "natural killer cells".' These are immune cells that are programmed to kill cancer cells and can therefore assist patients' weakened immune systems.' Dolstra initially managed to develop a successful production process of these cells at a medically applicable scale. After a first clinical study, the administration of the NK cells has also been deemed a safe therapy. 'Whether NK cells will become an effective treatment for leukaemia remains to be seen in follow-up studies,' says the researcher. 'If it works, then that would mean a safe, additional treatment for patients prior to a donor stem cell transplant.'

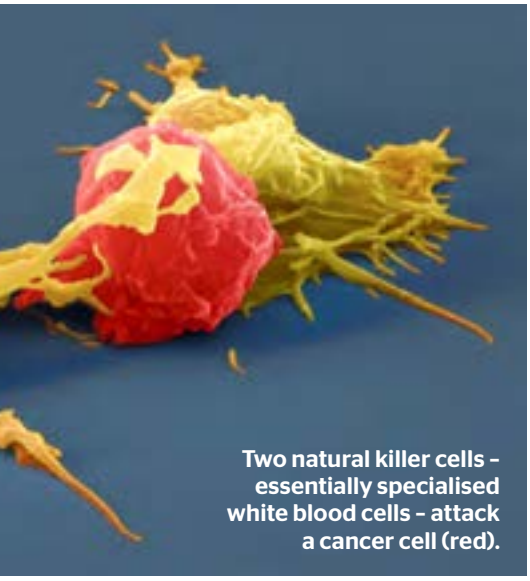


Members of the Marsdiep swimming club, founded in 1924, swim in the Marsdiep every day at 9 AM from May to October.

Heating a stove with calculations

Computers warm up when they're on. Even more so when you have a whole building full of computers, like a datacentre. Dispersing this heat is no easy task. At the same time, Dutch people still need to heat up their homes in the winter, no matter how many laptops they have lying around. Nerdalize, a start-up affiliated with the University of Groningen, has seized on the opportunity by heating up houses with the heat that's generated by the data centres. They're not delivering radiators to achieve this goal, but rather components from a supercomputer. They silently do their work in people's houses and simultaneously make sure that there's a nice temperature in the house. Together, the network of computer components can handle major calculation tasks. Nerdalize can offer these at a competitive price because the dissipation of heat is no longer a problem but an added value.

Feel cold? Turn up your supercomputer.



Two natural killer cells – essentially specialised white blood cells – attack a cancer cell (red).

Fewer failed medical studies?

Researchers are often confronted by the difference between laboratory animals and humans when developing new drugs: if a substance works in a mouse, that doesn't necessarily mean that it will also be effective in humans. Gunnar Klau has taken the first step towards making a better prediction of this 'translatability' at the *Centrum Wiskunde & Informatica*. The functional similarity between species is related to the activity and interaction of genes. 'We have developed a model that can predict the activity of genes in a situation that is familiar to us in both mice and humans,' Klau says. 'Now it's time to see whether we can do this for a new medicine too.' If they succeed in that, then fewer experiments will fail in the future and we'll therefore need fewer laboratory animals.

New knowledge will enable us to reduce the number of laboratory animals in the future.

IN BRIEF

Radiation can be an extremely complex affair, as is the damage assessment prior to treatment.

Better radiation treatment

Radiation treatment with radioactive particles is a common method for fighting cancer, despite the damage that it does to surrounding tissues. Doctors should weigh this damage against the benefits and develop a treatment strategy based on that. It's a highly complex task. Peter Bosman from the *Centrum Wiskunde & Informatica* is conducting research together with the Academic Medical Center and the company Elekta to find out what role ICT can play to ease the process. 'We want to develop programs,' Bosman says, 'that present the best possible compromises between the advantages and disadvantages so that doctors can identify alternative treatment plans as quickly as possible.' Intelligent computer models will then customise these plans for specific doctors and patients.

Cosmic lightning

Lightning activity in a thunder cloud can be triggered by energetic particles from space. This follows from extensive calculations by Anna Dubinova, Casper Rutjes and Ute Ebert at the *Centrum Wiskunde & Informatica* (CWI). Thunderstorms and lightning are complex, rapid and erratic processes that are difficult to study out in the field. However, the researchers managed to incorporate all relevant processes into a quantitative model. They predict that lightning can start from droplets or ice particles in the electric field inside the thunder cloud, as soon as free electrons are available. The electric fields are enhanced at the tips of the particles. The free electrons can be created when a cosmic particle with high energy bounces like the ball in a pinball machine between air molecules in the atmosphere, and breaks up more and more molecules, that also participate in the game. 'So if you look at a thunderstorm, then you know that it's coming from a cosmic particle from outer space!'

One simple measurement of the milk with your phone can expose doping.

Anti-doping test for cows

A cow given the hormone rBST produces more milk. It's forbidden in Europe. There are controls for this, but the tests are expensive and complicated. Maarten Merkx from the Eindhoven University of Technology received a Knowledge Innovation Mapping (KIEM) grant to develop simpler and cheaper controls together with RIKILT, the food safety institute. 'Our method uses two luminous proteins. They bind to the antibodies that the cow produces against rBST. The interaction of the luminous proteins and antibodies changes the light from green to more of a blue, which can be measured by the camera of any smartphone. 'So this test could be done directly on the farm,' according to Merkx.

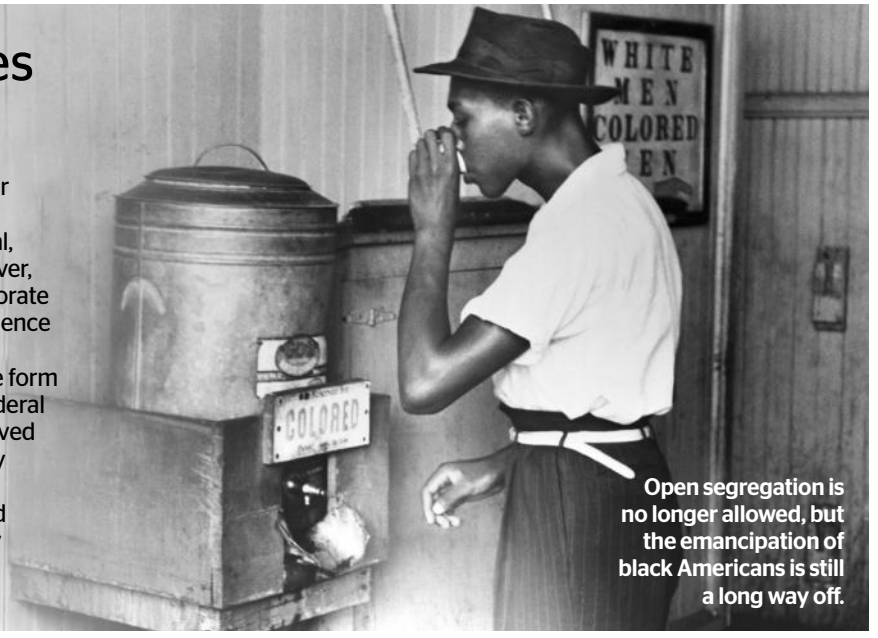
The free electrons that trigger lightning can be generated by energetic particles from space.

Ex-convicts have trouble finding homes

A good job and a suitable dwelling can make the difference for someone being released from prison. Anja Dirkzwager from the Netherlands Institute for the Study of Crime and Law Enforcement studied opportunities for ex-prisoners on the job and housing markets. 'We responded with fictitious people to vacancies and rental properties offered online. The e-mails mentioned whether there was any imprisonment or not, and applicant's names varied from Dutch to Turkish/Moroccan.' The responses from employers and lessors showed that ex-convicts don't have less of a chance at getting a positive response when it came to jobs, but they did when it came to housing. 'People with foreign names, however, had less of a chance on the job market, but not on the housing market.'

Racial terror still resonates after 150 years

Slavery was abolished following the American Civil War (1861–1865), and the federal government launched initiatives to provide black communities with more social, economic and political rights. Whites in the south, however, opposed these policies. Mark de Vries obtained his doctorate at Leiden University for his work on the strategies of violence used by whites. 'In the early years following the war, the violence against blacks was widespread and open, in the form of random beatings and murders. That prompted the federal government to enforce order. In response, violence evolved into subtler acts against specific people that were clearly meant to break the political will of the authorities.' As a result, the authorities intervened less often, which halted the emancipation of black Americans. 'Blacks never fully recovered, which is still evident in the southern states.'



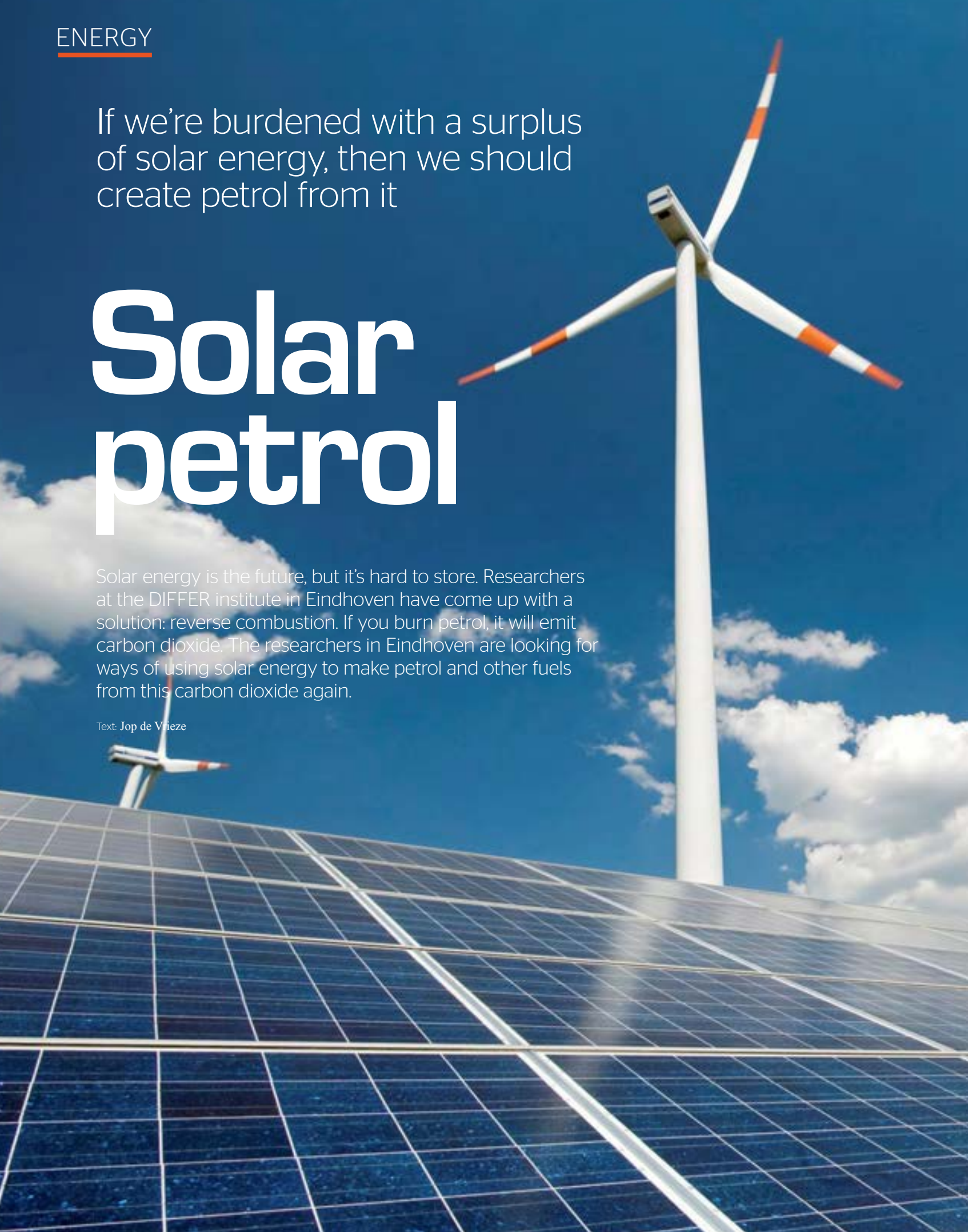
Open segregation is no longer allowed, but the emancipation of black Americans is still a long way off.

If we're burdened with a surplus of solar energy, then we should create petrol from it

Solar petrol

Solar energy is the future, but it's hard to store. Researchers at the DIFFER institute in Eindhoven have come up with a solution: reverse combustion. If you burn petrol, it will emit carbon dioxide. The researchers in Eindhoven are looking for ways of using solar energy to make petrol and other fuels from this carbon dioxide again.

Text: Jop de Vrieze



Great, all these wind turbines and solar panels, but what do you do with all the energy that they generate?

When the sun shines particularly brightly in Germany, strange things can happen. Because there are solar panels (and wind turbines) all over the country now, the amount of power generated can be so immense that it can cause the electricity network to break down, just like an extreme downpour can cause a sewer to flood. But there can be unwelcome consequences even when it doesn't end up breaking down. For one thing, there are no consumers for all of this electricity. The price therefore plummets so quickly that the producers don't get any money for it, but actually have to pay people to take it off their hands, as if it's industrial waste.

These kinds of problems could potentially affect the Netherlands too, because we are generating more and more energy from sunlight and wind. The problem is that there's no technology yet for storing this energy in an efficient way. That can be annoying when too much is generated, but equally so when the sun isn't shining much or at all and you do need a lot of energy. The available solution isn't ideal: to prevent the electricity network from breaking down, the electricity can be diverted to Norway for a fee, where it will be used to pump water into reservoirs. When we need a lot of electricity again, the Norwegians can empty their lakes to generate electricity. Then we can pay them again, this time to buy the electricity back.

Storage is tricky

The Dutch government wants us to use as much sustainable energy as possible. But if this supply of energy is going to mainly run on solar and wind energy, then we're going to have to find a way to store it more efficiently. That's why all kinds of technologies have been developed all over the world in recent years to make it possible to save electricity (see box 'This is how to store energy'). Examples include better batteries and flywheels. The disadvantage of all these technologies is that a lot of energy still gets lost. In most cases at least half of it disappears during storage and conversion, especially in the form of heat. Moreover, most technologies are not very flexible, which means it's not possible to switch quickly if there's a temporary surplus of solar energy on a beautiful bright day.

Gerard van Rooij from the NWO research institute DIFFER wants to do something about that. Based on the campus of the Eindhoven University of Technology, DIFFER is working on a completely different way of storing energy, ▷

‘Reverse combustion’ uses up CO_2 and produces new fuel

which builds on a technology that was developed in the Soviet Union during the Cold War. At the time, the Russians weren’t interested in sustainable energy or how to store it, but they were looking for a way to prevent their submarines from emitting carbon dioxide (CO_2) and betraying their position. CO_2 is created when you burn fossil fuels. Russian researchers thought that they could cover up the CO_2 by converting it into fuel again. That’s right, by applying the principle of reverse combustion.

Better than photosynthesis

In a normal combustion reaction, oxygen molecules form compounds with other molecules, such as hydrocarbons. Energy is released in the form of light and heat, and usually there is CO_2 as well. In reverse combustion, this CO_2 is broken down again with the aid of energy into carbon monoxide (CO), which is then used as a building block to produce fuels such as petrol and kerosene again. So reverse combustion doesn’t produce CO_2 – on the contrary, it uses it up. One advantage of this is that the energy becomes available for processes that don’t work on electricity, explains Van Rooij. ‘You can run a car on electricity, but an airplane needs kerosene because electricity is not powerful enough to get the plane into the air. About eighty per cent of our energy consumption still runs on these kinds of fuels.’

To be precise: fuels that consist of hydrocarbon molecules. Indeed, creating hydrocarbon molecules from CO_2 and sunlight is a trick that nature mastered long ago. Plants (and a number of bacteria) conduct photosynthesis, a process which enables them to engineer hydrocarbon molecules (in particular carbohydrates such as glucose). They source the energy for that from light particles (photons from sunlight), which they capture with green plant cells in their leaves. Nonetheless, Van Rooij’s preference is for his non-biological approach. It first generates electricity using solar panels, which is then stored in fuel molecules such as petrol with the aid of reverse combustion. ‘Todays’ solar panels are quite simply excellent, so we’ve essentially already outsmarted nature with that.’

Microwave makes plasma

The device that Van Rooij and his team want to use to convert the electricity is based on an everyday microwave. It emits electromagnetic waves, just like the device in our kitchens, but then in a small, narrow cylinder. The waves produce plasma in this cylinder, a gaseous substance in which some atoms have lost electrons. ‘You’re essentially detaching electrons from a small part of the CO_2 molecules with the vibrations of the waves, and these free electrons start to dance, as it were, on the electromagnetic field,’ Van Rooij says. These dancing electrons follow the waves of the microwave and collide with other CO_2 molecules, which fall apart and form CO. The researchers can then use these fragments of CO to create (in another process) high-quality molecules such as petrol and kerosene.

Right now reverse combustion is only possible in the lab, but perhaps one day we’ll be doing it on farms and in factories.

The technology is improving

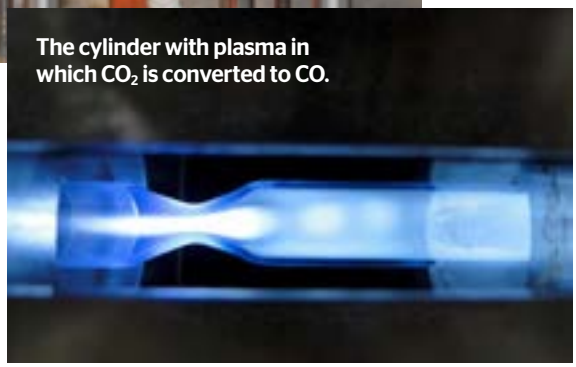
What’s important is that you break apart the CO_2 molecules with the vibrations as gradually as possible. If you do it too abruptly, then only forty kilojoules will remain for every hundred kilojoules of solar energy that you put into the fuel that you eventually produce. The gradual vibrating enables the researchers in Eindhoven to reach fifty per cent at the moment, but theoretically this could be increased to ninety per cent. That would mean losing only ten per cent of your energy. Most energy is still lost in the form of heat: the temperature in the plasma cylinder reaches 3,500 degrees Celsius. So for now it’s not realistic to

Dirty oil destroys catalysts

To make petrol, kerosene and other fuels from petroleum you have to process the oil in refineries. The less contaminated the oil is with metals and other substances, the easier it is to process it. But ‘clean’ oil is harder to come by. Indeed, it’s more profitable for oil companies to pump dirtier oil out of the ground. The result? The metal ions ‘poison’ the catalysts in the refinery that help to convert the crude oil into fuels. How this poisoning takes place has been identified by, among other people, chemists from Utrecht University under the leadership of Bert Weckhuysen, professor of inorganic chemistry and catalysis. A catalyst particle dies the same way an apple rots: the poison spreads from the peel to the core. The chemists discovered that with X-ray tomography, a very accurate kind of 3D X-ray scan. That means that a catalyst is already ‘dead’ before the core of the particle has been assailed by the metal ions in the dirty oil. We already knew that catalysts stopped working as effectively over time. Now the researchers also have an idea of how that process unfolds. With a bit of luck they can use that knowledge to come up with something to solve the problem.

Above: an apple rots from the outside to the inside. Below you can see that a catalyst particle is also poisoned from the outside first.

The cylinder with plasma in which CO_2 is converted to CO.



This is how to store energy

There are many ways of storing (electric) energy, each of which has its pros and cons.
Batteries: the electricity is converted by means of an electro-chemical reaction. Disadvantages: there is too much loss of energy through heat; the life of the battery is limited; and they're not particularly fast – charging an electric car takes a long time, for example. The yield is up to ninety per cent.
Capacitators: the electricity is not converted but stored as an electric charge. Unfortunately some of it leaks out as time passes, and high-capacity 'super capacitators' are still extremely expensive. The discharge is quick and sometimes hard to control.
Hydrogen: generated from water by means of electrolysis. Hydrogen can be stored and burnt as desired. This fuel is highly explosive, however. The yield is sixty to seventy per cent.
Flywheel: a flywheel is powered by electricity. It remains in motion and can generate electricity again by means of a dynamo. The yield is high, up to 99 per cent, but a flywheel requires too much maintenance for it to be used for large-scale energy storage.
Water: water is pumped up and later pumped back down, powering turbines that generate electricity again. But it's not very flexible and not feasible on a large scale in the Netherlands. The yield is about 75 per cent.
Magnets: the magnetic field of an electrical current in cooled, superconducting coils can be used to store electrical energy. There's a pilot installation in Japan that stores a hundred kWh and yields twenty MW of capacity. The disadvantage: it only works in extremely low temperatures. The yield is 95 per cent.
Compressed air: the electricity is used to compress air in an empty mineshaft, for example. When that air is released again, turbines are triggered to generate electricity. The yield is about 40 per cent.

Falling water that powered turbines used to be called 'white coal', because of the white foam.

produce fuel with it, all the more as the price of oil has been very low lately. That's why the researchers are still tinkering with the plasma setup. And they measure as much as they can so that they can map the fundamental processes at the foundation of the reaction more accurately: the temperature, the vibrations, the light production and the total conversion of CO_2. One of their aims is to have the reaction run just as smoothly as it would at a lower temperature. They do that by continuously turning the microwave on and off.

They're also experimenting by adding salt to the plasma. That disrupts the reaction a bit, as a result of which the temperature doesn't reach such heights and less energy is lost in the form of heat. One condition for this, however, is that the creation of plasma is not impeded then. That doesn't always go so smoothly, says Van Rooij. 'Once the salt melted, and another time it evaporated and ended up on the walls of the microwave before it could be added to the plasma.'

Thumbs up from politicians

The researchers from Eindhoven will continue their delicate work for the time being. Van Rooij hopes to have a clear picture in five years of whether the technique can be developed for general use. There's interest in any case: various major companies regularly come by to ask him how things are going. So, will we all have a microwave in our attics in a few years that's connected to our solar panels and which will create fuel from CO_2? 'I don't think so,' Van Rooij says. 'Because the couple of solar panels on my roof generate just enough electricity for my own household needs. And if my panels generate too much on occasion, then storage in a battery is a good solution for my small-scale situation. It would be more suitable on a farm or in a factory with many more panels. Then you'd need a kitchen microwave for every ten panels.'
In any case, there are many politicians who would be happy to have this technology, because anyone who can produce fuels from CO_2 doesn't need to import them from countries such as Russia anymore. The large-scale production of fuel from CO_2 with solar energy could potentially make us more energy independent. And that would be a welcome development in these turbulent times. □

LODI NAUTA, professor of the history of philosophy at the University of Groningen.

‘History is the philosopher’s laboratory’

Philosophy is the future

According to Lodi Nauta, professor of the history of philosophy at the University of Groningen, we still stand to learn a great deal from the major thinkers of the past. In 2016 he was the first philosopher ever to receive an NWO Spinoza Prize worth 2.5 million euros.

Text: Mark Traa / Photography: Johannes Abeling

You study the history of philosophy. Philosophers don’t need expensive equipment. What are you going to do with the 2.5 million euros?

‘I’m going to use the money to develop a new research group. By the way, we already have a fantastic group of historians of philosophy in Groningen! Now we can take a major step forward together in our study of the transition from a medieval to a modern worldview and perception of mankind. We’re going to make broad comparisons of how thought evolved from the Late Middle Ages to the Enlightenment.

I intend to appoint two postdocs and four PhDs right away, who are going to examine the genesis of modern Europe with us. Exactly which thinkers and texts we’re going to study is still up in the air because that depends on the people that I appoint, as well their interests and expertise. The best researchers are those who can follow their heart.

We’re also going to invite an eminent scholar to Groningen every year. He or she will teach a class, help coach our PhD students and be closely involved in our research. I already have a whole list of names. In addition, we have conferences and workshops planned about all of these subjects. As for me, I’d like the opportunity to withdraw every now and then to write and maintain and expand my ties with colleagues abroad. Strange, isn’t it? Despite all the attention that comes with the Spinoza Prize, what I’m most looking forward to are the moments of tranquillity and contemplation so I can write and think.’

What part of history do you want devote more attention to?

‘When you think of the history of philosophy, you usually think of the peaks: Spinoza, Kant, Nietzsche, Plato, Aristotle. That’s the canon of philosophy. But these peaks are surrounded by high mountains that have kind of fallen by the wayside. We often say that modern philosophy began with Descartes: “I think therefore I am.” But he also leaned on philosophers that were rooted in older traditions. Even though he rejected them, they undoubtedly influenced his thinking.’

How are you going to research that?

‘We’re going to examine the original sources, the old manuscripts. Read what these people thought. Ultimately history is the philosopher’s laboratory. We don’t head out into nature, like someone who studies migratory birds. When we think about free will, we want to spar with people who thought about it in the past. That’s why history is always current for philosophers.’

What kind of new insights do you expect to encounter?

‘Oh, many, very many. History is in a permanent state of flux. Interpretations are constantly changing. And then there are so many sources that haven’t been studied yet. There are a huge number of unread manuscripts in libraries, especially from the Middle Ages.’

Can you recall one of your discoveries?

‘When I was doing research for my PhD I discovered a text that wasn’t written by the person that was supposed to have written it. The text was from a century later. That wasn’t a discovery that turned the field upside down or anything, but for me, as a young researcher, it was special. Later there was another case. I found things in the original manuscripts by Johan Huizinga, the famous Dutch historian from the first half of the 20th century, which confirmed my interpretation of him. Things like that are often found in small details. Even deletions in original manuscripts can be important.’

You’re a fanatic birdwatcher. In addition to analysing, it seems observation is in your DNA.

‘In this profession you have to do both: combine the traditional ▷

‘I do like down-to-earth philosophers’

Who is Lodi Nauta?

1966: born on 19 October in Groningen.
1985: foundation course in biology at the University of Groningen.
1986: studies philosophy and medieval studies in Groningen and in York.
1996: works at the university library in Groningen.
1999: obtains his doctorate cum laude for his dissertation on philosophy in the Middle Ages, becomes postdoctoral researcher and university lecturer.
2000: receives the Keetje Hodshon Prize for his dissertation.
2001: receives an NWO Vidi grant for the research programme ‘The Critique of Language in the Philosophy of the Later Middle Ages, Renaissance and the Twentieth Century’.
2005: becomes university associate professor and member of The Young Academy of the Royal Netherlands Academy of Arts and Science (KNAW).
2006: becomes editor-in-chief of the philosophical journal Vivarium, A Journal for Medieval and Early-Modern Philosophy and Intellectual Life.
2007: becomes professor of the history of philosophy at the University of Groningen.
2008: guest lecturer at Harvard University Center for Italian Renaissance Studies in Florence.
2009: receives an NWO Vici grant for the research programme ‘Humanists as Philosophers: The Place of Renaissance Humanism in the History of Thought’.
2009: wins awards for his book about Italian humanist Lorenzo Valla.
2011: member of KNAW.
2013: chairman of the jury of the Eureka Prize for science communication.
2013: becomes dean of the Faculty of Philosophy in Groningen.

legwork with analytical thinking. I find that to be one of the most appealing sides of my work. I originally started studying biology as an undergraduate. I was interested in ecology, but that wasn’t taught in the first year. At the same time, I was also very interested in classical languages and literature. Sure, cutting open and drawing dead rats was fun, but I missed the culture and the history. I considered studying the liberal arts, but to do that I needed the right foundation course. I chose philosophy. It wasn’t long before I added medieval studies to that.’

How would you explain the importance of your subject to a layperson?
‘The layperson is well aware that you have to dust off a Rembrandt to see the master at work. That’s cultural heritage. Imagine if we didn’t do anything with our intellectual heritage. That we never read Descartes again. Or Plato, Hume and Kant. That would be mean severe cultural impoverishment.’

What would be lost?
‘These thinkers came up with important ideas on just about everything you can think of. We can still learn from that. What makes life valuable? What is good and evil? What is beauty? What makes an argument valid? What’s the relationship between mind and body? Is there such a thing as free will? These are questions that have occupied an incredible number of people over the centuries. These questions will always be asked, and in that sense philosophy definitely has a future. By nature people have a need to think about more than just the here and now. Take free will: what is it actually? You don’t see it when you cut a person open. But the concept is extremely important, for example in a court of law. It is the philosopher’s task to analyse and clarify these kinds of concepts. And it’s important that they continue to do so. The shifts in thinking about such subjects, affected by religious, political and social change, are what make philosophy fascinating. Don’t forget that it change the way we view our position. There are thinkers who were innovative and original in their time but who are of little use to us today because the times have changed so much. (Of course that does make them historically interesting.) This can happen to matters that we take for granted right now. People might look at them differently in 500 or 1,000 years.’

You focus on the Middle Ages and the Renaissance. Why are these such important periods?
‘All periods are interesting, actually. But take the Renaissance: man’s worldview completely changed then. Modern science was emerging, the Reformation broke out, new parts of the world were discovered. The old worldview, rooted in Aristotle and the bible, was no longer able to answer people’s questions. You see it slowly unravelling, and that’s fascinating to watch. It’s an amazing period to study. But that goes for the Middle Ages too, which are wrongly depicted as a dark period. You can only understand the genesis of mankind if you consider the whole history. That includes antiquity, which later rears its head everywhere.’

If you could take H.G. Wells’ time machine for a ride, where would you go and who would you like to speak to?
‘Then I’d have to go for antiquity. And I would want to walk

through ancient Athens with Socrates, one of the founders of western philosophy. He had a group of young people around him with whom he philosophised about a number of different subjects. I would love to be one of those young guys for a day. I can't think offhand what I would ask him, but he was such a charismatic figure. Incidentally, Socrates had to pay with his life for the fact that those in power believed he was corrupting the youth.'

Do you ever talk with the philosophers that you study?
'Not literally. But of course we can still learn from the heroes of the past. Philosophy is not an empirical branch of knowledge, where you know at a certain point that you're done because you've figured out what causes metal fatigue. We ask mainly theoretical and conceptual questions. In that sense we are in a dialogue with philosophers from the past. Why did you say that? What did you mean by this? Doesn't this contradict what you said earlier?'

You wrote a much-praised book about Lorenzo Valla, an Italian humanist from the fifteenth century. In the foreword you warn of the danger that philosophy is becoming so abstract and technical that only a small group of the initiated can still understand it. How do you convey it to people?
'By giving occasional lectures to a large audience. And I'm also contributing to an introduction to philosophy. I do think it's important that academics show people what they do. But they also have to write specialist articles. There's a danger in that, because before you know it you're introducing some technical terms and creating a school that people want to follow. These people can get completely wrapped up in the jargon of philosophers such as Heidegger, Hegel and Sartre. And then out of the blue it can start to have sectarian characteristics.'

Do you have a predilection for a particular movement?
'I do like down-to-earth philosophers. In the 1950s you had ordinary language philosophy in Oxford, which opposed philosophers who invented fancy technical terms for a given phenomenon. In Oxford they said: understanding starts with ordinary language. How do we actually talk about a concept such as beauty? First take stock of that and then don't immediately discard ordinary language. I like that. It's also a warning: language is not something that you can manipulate according to your own whims by inserting it into your own little theory.'

By choosing philosophy were you looking to answer some questions that were occupying you personally?
'No, I was simply fascinated by the idea of learning how to think incisively about ethical or academic questions. And I thought the historical aspect was great. I was lucky to have been taught by someone like John North, a modest man who exuded great erudition. He not only knew a great deal about the history of philosophy but also about astronomy. He has passed away in the meantime (Nauta takes a picture out of a cupboard depicting the two men, ed.). It was partly out of some kind of vanity that I quickly realised: I want to be someone who is that erudite.'

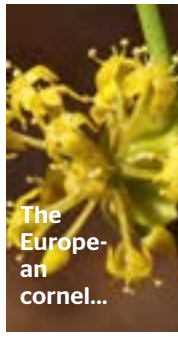
We can now safely say that you have succeeded in doing that.
'Oh no, I'm just a mere mortal compared to North. But in the category of mortals you could probably say I'm getting there, yes. Strange, isn't it?' □


Yum, porcini!


Wild hops: not suitable for beer.


Blackberries are very popular.


Sweet chestnuts in the wild.


The Europe-an cornel...

Why do Dutch people rarely forage for a meal?

Wild foraging

In many European countries, people still regularly forage in forests to put together a meal of wild plants and mushrooms. Who are these foragers? And why is it a rare sight here in the Netherlands?

Text: Elly Posthumus

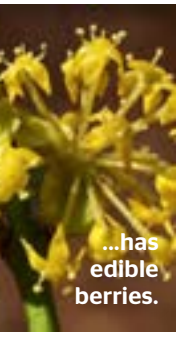
Most people in the Netherlands are barely able to distinguish between edible and inedible plants or berries anymore. Foragers in other countries feast on all kinds of wild vegetables, mushrooms and herbs. Nynke Schulp from the VU University Amsterdam examined where Europe's biggest foragers are and why they turn to nature for their food. 'It's not really necessary in terms of calorie intake,' she says. Even in countries with the most foragers only a small portion of their food comes from foraging in the wild. So why do they do it? Above all, foraging is a tradition. In Scandinavian countries, entire families head into nature in the late summer to spend the day gathering berries and brambles. Sometimes we're talking about considerable amounts. In Finland, for example, the amount of berries people pick can constitute a third of the country's entire fruit consumption. And of course, people like to be in nature. Yet the Dutch rarely go in search of edible vegetation. Why is that?

Wild recipes

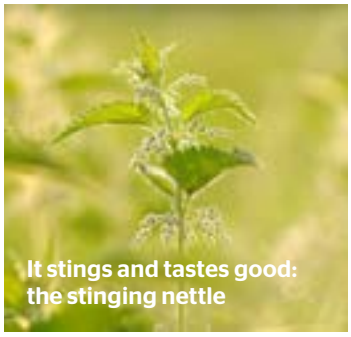
A lack of knowledge is one of the reasons, Schulp suggests. 'Wild mushrooms in particular often look very similar to each other. That presents a problem, because some are not tasty at all, or worse they're poisonous. Moreover, you need to know where to look. Edible plants often grow in very specific places. So you need a bit of knowledge about your environment to find them.' This knowledge is usually transferred from parents or grandparents to children. But people in the Netherlands stopped doing that some time ago. 'We switched over to agriculture and trade at a very early stage here. As a result, wild foraging and the knowledge needed to do it have all but vanished.' The Dutch aren't exactly sure what to do with these wild herbs and plants. You rarely come across them in cookbooks. 'But open a cookbook in Italy and it will be full of recipes with wild mushrooms and vegetables, such as wild spinach, wild arugula or wild asparagus,' Schulp says. And all of these ingredients can be found there. The variety of edible foods is greater in countries with a foraging culture than in the Netherlands.


Protected wild strawberry: hands off!

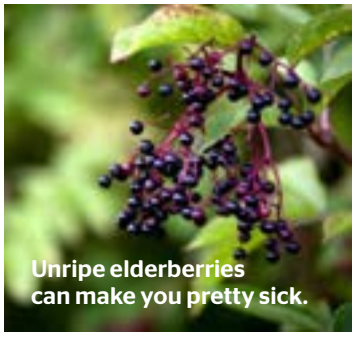
'Mushrooms, for example, are primarily found in cluttered forests with old wood,' Schulp explains. 'We've hardly had any of these in the Netherlands for a long time now. They're starting to make a comeback though. But however you look at it, in Eastern Europe you have a much greater variety of edible species. There, mushrooms are really part of the traditional menu.'



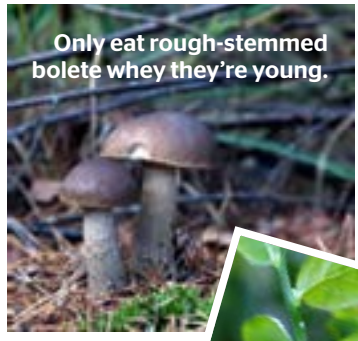
...has edible berries.



It stings and tastes good: the stinging nettle



Unripe elderberries can make you pretty sick.



Only eat rough-stemmed bolete whey they're young.

Rare: wild garlic.

As a reaction to globalisation, some urbanites are resorting to wild foraging. Not everyone is equally pleased about this.

The European blueberry, a source of vitamin C.

Raspberries can be picked from July to September.

Seek and ye shall find hazelnuts.

Where's the forest?

There are other reasons why the Dutch are not great foragers. 'Officially you can't forage anything here,' Schulp says. 'The blackberries and blueberries belong to the owner of the area, such as *Staatsbosbeheer*, the forest management agency.

But owners usually turn a blind eye to foraging, as long as the entire forest isn't plundered. A landowner usually won't mind if you take some blackberries for a jar of jam.' The rules are less strict in foraging countries.

The Netherlands is considerably urbanised as well. 'Many people here live in cities,' says Schulp. 'So they don't get out into nature as often as the average Italian, for example.' It should be mentioned that Europe is becoming urbanised everywhere, which is causing the foraging culture to slowly diminish even in countries where it has a tradition. Moreover, many people associate the foraging of wild plants with poverty and hunger. Older people, who are precisely the ones that can transfer the knowledge, make that association. That, and rising prosperity, means that wild foraging is increasingly being put on the back burner, even in countries where it has been traditionally popular.

Hipster in the forest

And yet something has been changing in recent years in the Netherlands. You're increasingly likely to come across hip urbanites scrounging together a meal in nature these days. They hire a guide and take a wild foraging hike or they attend a workshop to learn how to cook with wild green grub. This is probably a reaction to globalisation. 'We are increasingly concerned about healthy food and local traditions, and wild foraging fits in perfectly with that.' Some conservation organisations are less than happy about this development. They fear that hordes of planet aficionados are going to disrupt reserves. Nor are wild foragers always concerned about the protected status of plants. The wild strawberry, for example, is on the red list in the Netherlands, but some wild foraging websites tell you exactly where to find this plant.

Oh well, maybe all this foraging has a positive side to it. 'Because more people are spending time out in nature, they are devoting more attention to it and learning to appreciate it. They are becoming increasingly aware of the consequences of urbanisation and other threats.' With a bit of luck, this will make them take better care of nature. □

MORE INFORMATION

wildplukwijzer.nl: this site shows you exactly where you can forage in your area.

A lesson in picking

In addition to blackberries and blueberries, there are many other edible fruits and plants in the Netherlands, such as raspberries, stinging nettles, wild garlic, hops, elderberries, hazelnuts and sweet chestnuts. The wild strawberry and the fruits of the European cornel can also be found here, but they are protected plants. So, hands off! If you want to go foraging, the Royal Netherlands Natural History Association (KNNV) has the following tips to keep the burden on nature to a minimum:

- Only forage for plants and fruits in areas where you are allowed to be. Protected areas are forbidden territory.
- To avoid being poisoned, only forage for plants that you know and are completely sure that they are edible.
- Don't take more than a tiny amount of what's growing there. If you take all the plants or fruits growing in a place, the species could disappear there. Moreover, it would be courteous of you to leave some standing or hanging for the animals that depend on it.
- Don't crush other plants while foraging and don't break off any branches. Never dig up a plant.
- Keep in mind that as soon as you enter the forest, you could be disturbing animals such as deer, badgers, birds and soil fauna.

CREDITS

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Editorial team NWO
Marcel Senten
Domien Huijbregts
Marije Huiskes-Tolsma
Joost de Man
Mirjam Visser
Gieljan de Vries

Project manager NWO
Jennifer Schuytvlot

Translator
Mark Speer

With the help of (NWO)
Renske van den Berg, Ursula Bihari, Surya Bonam, Jan Boon, Gaby van Caulil, Siska Clarysse, Lieke van Emmerik, Ans Hekkenberg, Peter Hildering, Annemarijke Jolmers, Sharmila Karia, Annette Kik, Tessa Knaake, Marianne Kroon, Tessa van Leeuwen, Manoe Mesters, Maarten Muns, René Prop, Petra Rodriguez, Melissa van der Sande, Frans Stravers, Aschwin Tenfelde, Nico Voskamp, Anouck Vrouwe, Frank Weerman, Martijn Wienia, Gabby Zegers, Sabine Zinsmeister

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Editorial address
Redactie *Quest*,
Zuidpark,
Spaklerweg 52,
1114 AE Amsterdam-Duivendrecht
tel: 020 - 79 43 500
e-mail: redactie@quest.nl
internet: www.quest.nl

Sales
Corine d'Haans (CCO), Raymond van Kasterop (sales director), Edwin Rijken (sales manager), Jerome Thenu (traffic manager)
Telephone Sales: +31-(0)20-79 43 564

Production management
Hans Koedijker, Anouk van Kuilenburg

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Johannes Abeling.

Robot cleans vertically

Robots have been mowing lawns and hoovering for years. Thanks to KITE Robotics, window cleaning has been robotised now too. Together with the University of Twente (and with support from the Technology Foundation STW), the company developed a robot that cleans façades and windows. A cable system enables it to effortlessly find its way around the façade. It uses its red brushes to clean corners that are hard to access. 'The device is already being used by various cleaning companies,' says Stefan Spanjer from KITE Robotics. There is interest from abroad now too. Should window cleaners fear for their livelihoods? No, someone has to hang the cleaning robot onto the façade and operate it, but this robot does make their work less dangerous.

The bacteria that produces the 'Leiden' antibiotic is very lazy.

Nipping pathogens in the bud, page 38

The emphasis in sex education is still on the risks and not on the pleasure of sex.

Adolescent love and sex, page 68

Our teeth resemble fish scales.

Open wide, page 50

14 September 2015, just before 1 PM Dutch time, was a historical moment.

Chasing space ripples, page 54

You can hear but not see some defects in the tracks.

Tuning in to the tracks, page 44

NWO op YouTube

If you're interested in seeing more NWO research, visit www.youtube.com/NWOwetenschap. There are hundreds of videos there about Dutch scientific research, from women's football and neutrinos to quantum mechanics and philosophy.

Science in focus? NWO on YouTube!

NWO Spinoza Prize

Meet the scientists who can change the world. NWO Spinoza laureates talk about their work and other passions in videos filmed by students from the University of Amsterdam. The NWO Spinoza Prize is the highest scientific distinction in the Netherlands. NWO awards the prize to researchers who work in the Netherlands and belong to the absolute top of science. The laureates conduct outstanding, groundbreaking and inspiring research.

PLAYLIST: *NWO Spinoza Prize and Spinoza laureates*

Responsible innovation

Technological development can fail if it neglects to take ethical and social consequences into account in good time. Examples include electronic patient records, CO_2 storage in Barendrecht or the 'smart energy meter'. NWO's Responsible Innovation programme funds and encourages research on the ethical and social aspects of new technology.

PLAYLIST: *NWO Responsible innovation*

Creative industry

Via the theme 'creative industry', NWO is investing in scientific research by, for and about the creative industry. Creative industry is the collective name for fashion and industrial designers, architects, advertising agencies and the creators of software and games. It also covers media and entertainment, the arts, cultural heritage and cultural events.

PLAYLIST: *The creative industry theme*

www.youtube.com/NWOwetenschap

SCIENCE IN THE NETHERLANDS

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