Movable chip layer makes chip smarter

Chips out the oven

The Twente high-tech company SolMateS can provide computer chips with a moving layer. You can use such a smart chip to project a film from your phone onto a wall. How do you come up with something like this?

TEXT: AMANDA VERDONK

Oh what fun a party in 2012 can be with half the people just sitting there staring at their phones. Busy texting, whatsapping and facebooking. Fortunately smartphones are now available that can project your phone screen onto a wall so you can watch funny films or the latest holiday photos together. Perhaps that will help to brighten things up in the future. Unfortunately, the current generation of projecting phones use up your battery in no time. But with a new type of chip that will be a thing of the past. The chip has a movable layer which can allow hundreds of tiny mirrors to move. You can turn your phone into a projector by shining a lamp on it.

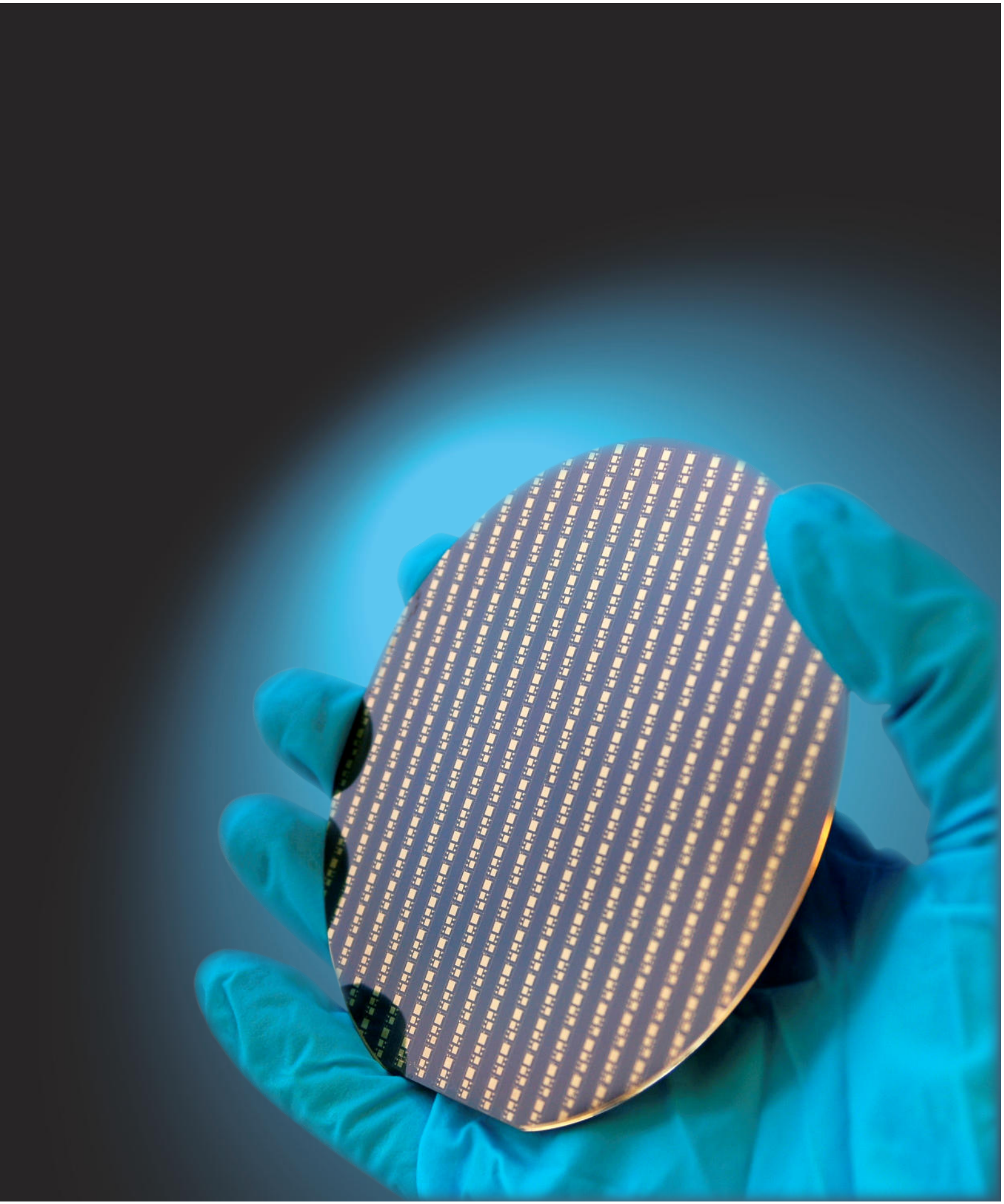
Besides allowing mirrors to move, such a multifunctional chip can also activate sensors or pumps. Place such a chip on your car tyre and a sensor can measure the tyre pressure. And what about cheaper and faster printer heads? If you want to print something, a printer head moves nervously backwards and forwards. These are very expensive parts and so manufacturers make them as small as possible. But with this technology you can make a printer head a page wide because on a moving chip you can incorporate the holes and pumps for the ink. That saves several expensive steps in the production process.

Oven makes red sauce

The young Twente technology company SolMateS makes these digital all-in-one devices possible. Director Arjen Janssens explains: 'The chip is like a pizza. The silicon base is nearly always the same, but the red sauce and toppings give variety. We offer a different type of red sauce.' And that red sauce is a movable layer in which the special layer is not tomato but a 'piezoelectric material'. This stone-like stuff can move. Janssens explains: 'If you apply a voltage across it the material changes shape. The opposite is also true: if you put the material under pressure it produces a voltage.' You can use this technique to make something move or to activate a sensor or pump. SolMateS manufactures the 'oven' you need to produce the red sauce. This 'oven' measures 1 by 2.5 metres. Inside, a very powerful laser beam strongly illuminates the piezoelectric material. Heating it up to more than 10,000 degrees Celsius. This causes the material to fall apart into individual atoms that are then neatly arranged on the 'pizza base'. The device from SolMateS can make a single layer on such a chip. Far more 'toppings' are applied, that could easily be thirty. before the chip is ready and for a computer or phone. A separate device is needed for each layer. Chip producers like Intel or Samsung have large halls full of more than 100 devices that each apply a single layer.

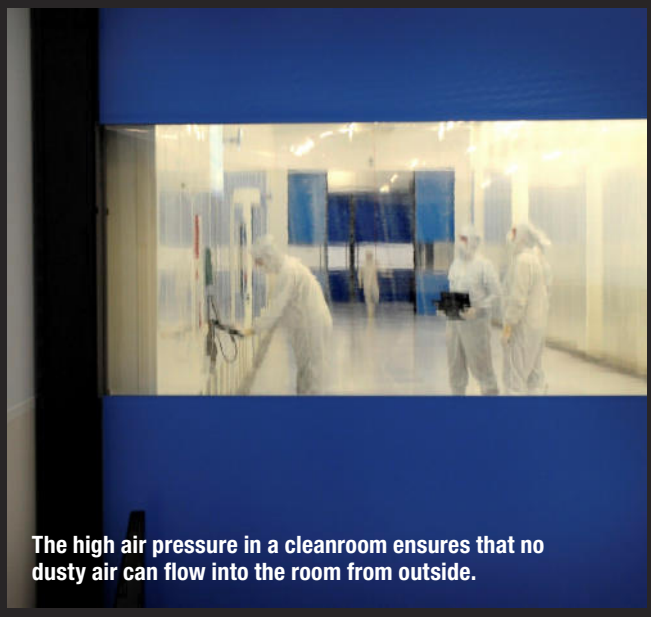
Knowledge becomes profit

The moving special material that SolMateS uses is not new. Several years ago, at the University of Twente, Janssens studied the piezoelectric material in great detail. Back then he did not realise he was holding a fortune. 'Scientists come up with many solutions without knowing which problem these belong to. The solution and problem are often formulated separately. For example, we had never thought about the printer heads.' ▶



How do you convert knowledge into cash?

Some companies saw the possibilities but failed to get the material under control. Janssens knew the University of Twente possessed the knowledge needed to achieve that. With three other materials scientists from the university he set up the company in 2006. The challenge: bringing scientific knowledge to the market. In other words: from knowledge to cash. 'Researchers like to focus on exciting stuff and continually discover new things. They want to find the boundaries of materials. A company only needs to know so much. You cannot endlessly keep on improving things. Instead, you need a stable process that you can always repeat exactly. That is really hard.'



The high air pressure in a cleanroom ensures that no dusty air can flow into the room from outside.

Sun changes product

Getting the material onto a chip correctly is a very delicate process. The right temperature and amount of oxygen must be spot on. 'You need to control that enough to repeat it 1000 times, as the client wants a guaranteed quality.' Developing such a standard process is a challenge with many ups and downs. 'When we were still in another building, the laboratory was too hot sometimes. When the sun shone we suddenly had a different product,' chuckles Janssens. With two discarded air conditioners from another building they got that under control. Now the entrepreneurs are able to continually reproduce the same quality and sold their first two systems. They will build that on location in the client's dust-free cleanroom. 'We are still in the test phase and then it is less important if a few dust particles are found in the device. We will soon move to our own cleanroom in the building of High Tech Factory where we will walk around in those white suits.' Then all that playing around with air conditioners and other hassles will be behind us. ■

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Lab-on-a-chip

You are sitting in a restaurant and about to put a spoon of soup into your mouth. But you are allergic for gluten (wheat) and so want to ensure the harmful ingredient does not end up in your stomach. The technology from Twente can help you. A drop on a chip can show whether this soup is gluten free. The moving part of this chip pumps around a bit of the fluid past a sensor that sends a signal if the culprit is detected. Similar applications are possible for analysing blood on such a lab-on-a-chip. If you suffer from manic depression, for example, then you need to monitor the lithium level in your blood. Using the chip will save you a visit to the doctor.

Dutch glory

Just like skating and swimming the construction of chip machines is a Dutch speciality. ASML, the world leader in that area, is based in Veldhoven. The world's three largest chip manufacturers, Intel, TSMC and Samsung, all have shares in the company. ASML manufactures equipment that illuminates a photosensitive layer between each layer of the chip. ASML is not a competitor of SolMateS. On the contrary, Janssens is happy to have them. 'We benefit because ASML outsources so much. A specialised high-tech industry has therefore developed in the Netherlands. Many of those suppliers also deliver to SolMateS. For example, the stainless steel coating of the reactor chamber. That is specialised made-to-measure work that must be milled to an accuracy of within a tens of millimeters.

ASML also makes devices that can process layers on chips. Thanks ASML's success there are many high-tech suppliers in the Netherlands.

FURTHER INFORMATION

www.solmates.nl: website of the Twente chip-producing machine manufacturers.

Steering aid

NWO funds talented scientists with an innovative research plan. The Veni grant is for researchers who have recently gained their PhD and is worth up to 250,000 euros. The Vidi grant is for more experienced scientists and is worth 800,000 euros. The Vici is for senior scientists and worth 1.5 million euros.

Why exactly were you chosen?

'I think my proposal was good, and NWO had confidence in me realising it. I am experienced in investigating how to support humans in controlling aeroplanes and cars. I worked on several projects at Delft university for Nissan and Boeing, showing that my fundamental research can also lead to practical applications that interests industry. I think that this, together with the rare combination of research skills required to complete the proposed research, is what led NWO to award the grant.

What are you using the money for?

'We investigate how to best combine humans with intelligent vehicles. Cars can be equipped with sensors, which could communicate dangerous situations through warning signals. But these are usually annoying, so we are looking for a more intuitive system. Imagine you want to change lanes on the motorway. You should not do that if another car is too close. Drivers can of course see that, but we do not always look carefully enough. We propose that if the car notices the danger via the sensors, smooth forces, instead of a warning system, are used to make it harder to steer towards what the car perceives to be unsafe. Effectively the car says: 'I would not do it if I were you, but you're the boss'. The driver is immediately aware of the danger, but can still decide to make the manoeuvre by applying more force to the steering wheel.'

'Our research has revealed that people respond quicker (using their reflexes) if they literally feel something from their environment in the steering wheel, compared to a response to visual information. There is a relatively large delay between changes in the environment and the visual translation of this in the brain. By mapping changes in the environment to forces on the steering wheel, that translation becomes much faster. The driver, however, always remains in charge of the car. Still in control, but more aware.'

How did you end up in this line of work?

'I studied mechanical engineering in Delft and focussed on research at the boundary between humans and machines. At a certain point I was fed up with that study and switched to philosophy. My professor persuaded me to finish my mechanical engineering study and sent me to a research group in America, where I investigated ways to assist paralysed patients. That was very tangible and got me enthusiastic to finish my studies with a very interesting assignment.

After my graduation, my professor phoned me to ask if I wanted to do a PhD. I refused, because I also play drums and wanted to be a full-time musician. 'Start with two months,' he said. I did, and was allowed to work so that I could combine being a musician with working at the university, and still do so to this day.'

What would you still like to investigate?

'Usually engineers choose for complete automation of a (sub)task, or to let people do it manually. Full automation is hard to realize. We still want pilots on a plane. The world is not predictable and sensors are not always reliable. A fully automatic car now exists. This can be dangerous in some conditions, even if it can help prevent accidents. If it goes wrong, it will go badly wrong. I want to understand humans so well that we can develop a system that responds just as fluently as a human, and can communicate its intent and authority to humans very intuitively. ■

DAVID ABBINK (35),
biomechanical engineer at Delft University of Technology received a Veni grant in 2009.

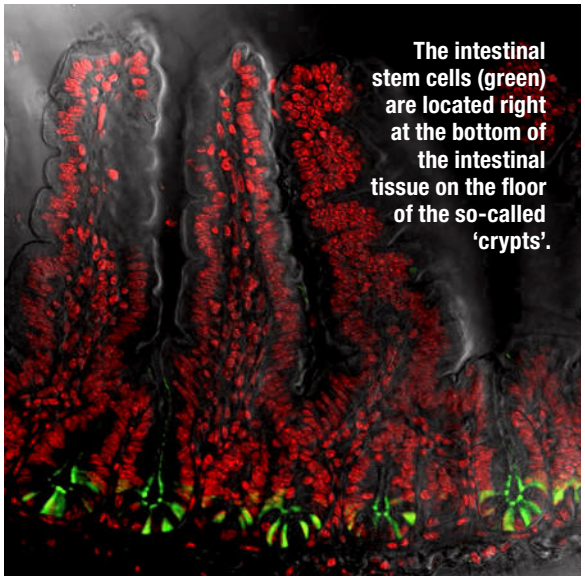
Stem cell helps research into intestinal diseases

Organ demystified

Utrecht biologist Hans Clevers has grown a part of the intestine in a petri dish from just a single stem cell. He wants to use this technique to repair the intestines for people with an intestinal disease. Furthermore the cells are helping research on how cancer develops.

TEXT: HIDDE BOERSMA

'Look a piece of intestine.' Hans Clevers from the Hubrecht Institute in Utrecht points to a petri dish containing a tiny tubular object barely visible to the naked eye. He pushes it under a microscope. Now clear structures are visible. Some lumps of cells seem to be random strands, whereas others form a beautiful circle. Clevers: 'They do that automatically. If you let these cells grow for long enough they automatically assume the shape of an intestine. With the inside neatly on the inside and outside on the outside.'



The intestinal stem cells (green) are located right at the bottom of the intestinal tissue on the floor of the so-called 'crypts'.

It is a daring exploit by Clevers' lab: culturing organs, or at least parts of them. So far it has mainly been mouse intestine as you can and may do more experiments on this than on human material. Clevers hopes that one day his research will result in new intestines being cultured for people with intestinal diseases. He also uses the intestines cultured to investigate the development of intestinal cancer, one of the most common types of cancer.

Adult is handy

What makes Clevers' work so special is that he allows organs to grow from just a single stem cell. Ordinary cells are continually dying and being replaced, but stem cells have eternal life. They divide and their daughter cells lay the basis for all cells in your body. There are two types of stem cells: embryonic and adult. Embryonic stem cells do their work in the womb. They can develop into anything and they therefore form your entire body with all its organs. Adult stem cells are found in the mature organs and are partly specialised. Stomach stem cells can still form all types of stomach cell but can no longer grow into a brain cell, for example, as these do not occur in the stomach.

'Working with adult stem cells is handy if you want to culture organs,' says Clevers. 'Then you know that no unpleasant surprises await you when the cells develop further, for example, an intestinal cell in a lung cell.' Adult stem cells are present in all organs but were first discovered by Clevers in the intestine. 'The intestines are the organ that renews itself fastest. Every five days the inside of the intestine, the part that absorbs nutrients from food, is completely refreshed. This means that extremely active stem cells must be located there, which is why they are so interesting to study.'

Cell present in crypts

When Clevers started on his research some twenty years ago, almost nothing was known about intestinal stem cells. Nobody knew where they were located let alone how they worked. The first step was to find the cells. They were located about five years ago. Intestines are not smooth hollow tubes but contain so-called intestinal villi, protru-

A new intestine can already grow in a mouse

To see how intestinal stem cells formed intestinal tissue, Clevers stained stem cells in different colours. This allowed him to discover which cells make normal intestine and which cells form cancer tissue. So these colourful images are vitally important in the fight against cancer.

Who is Hans Clevers?

Hans Clevers was born in Eindhoven in 1957. He did not one, but two university degrees. In 1984, he graduated in biology and medicine from Utrecht University. Just two years later he gained his PhD from Utrecht in immunology. He continued his career in the United States at Harvard University in Boston, Massachusetts. 'A prestigious university,' he says. 'But the work pressure and competition were very high. Working here is more fun.' So he returned to the Netherlands in 1989 and two years later he became a professor at the university where he had studied. In 2001, he received an NWO Spinoza Prize and a year later he became director of the Hubrecht Institute. In 2012, Clevers succeeded Robbert Dijkgraaf as president of the Royal Netherlands Academy of Arts and Sciences.

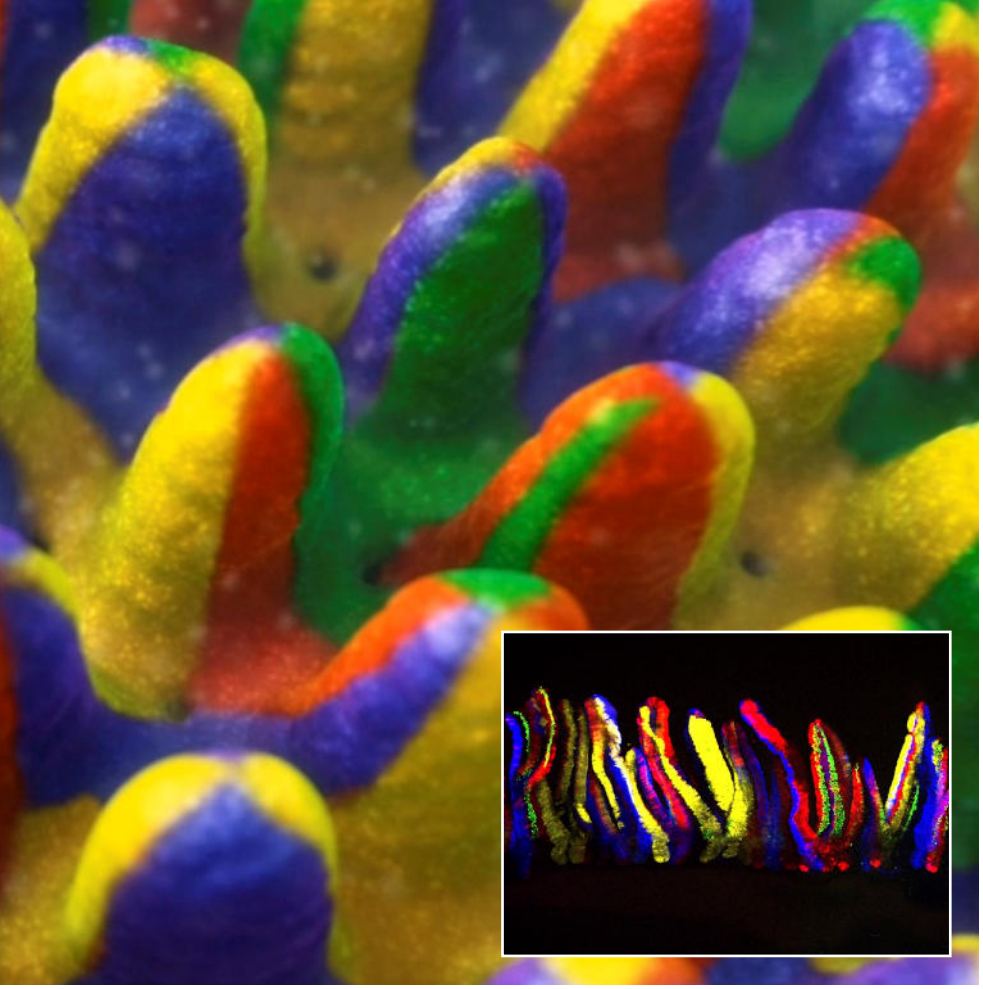
sions in the intestinal wall that increase the surface area of the intestine. That enables the intestine to absorb food efficiently. Immediately next to the villi are tiny cavities called 'crypts'. After a long search, Clevers discovered that intestinal stem cells are located in the floor of the crypts. Each cavity contains about 15 stem cells. These continually divide and daughter cells develop into the different types of intestinal cell. New cells are continually pushed up from the bottom. On reaching the top, these rushing youngsters replace the old cells that slowly die.

Once Clevers had found the stem cells, he started the next project: he wanted to remove them from the body and let them grow into intestine in the lab. To carry out this plan successfully he needed to know exactly what makes such a cell a stem cell. What is needed to cause stem cells to divide and develop? After years of slogging away at the problem he and his team found an entire series of genes that influence each other and are specifically activated in stem cells but not in normal cells. 'When we added four proteins that regulate these genes to a liquid containing stem cells, the stem cells neatly grew into small intestine outside of the body.'

For his research Clevers needs miniature pieces of intestine. He lets these grow from 'adult' stem cells in mice (see above).

Intestine grabs intestine

It was an important breakthrough, one which gave hope to people with an intestinal disease. Perhaps they could receive a new piece of intestine. To test if that is possible, Clevers and his colleagues took some pieces of intestine with them to Japan. There scientists had developed mice without a food-absorbing layer in the intestines. In a joint project they injected tiny pieces of intestine formed from stem cells rectally into the mice. The treatment works superbly. Small pieces of intestine attached to the intestine of the mice in exactly the right manner. The outside of the intestine settled in the intestine after which the small tube opened up so that the inside was exposed and could do its work. Clevers is cautious about being too optimistic. 'It will be at least another 10 years before such operations can be done in a hospital.'



Stem cell causes cancer

The success of Clevers' research did not, however, stop with the culturing of intestines. He discovered that stem cells were not only responsible for the continual renewing of the intestines, but that they were also involved in the development of intestinal cancer. This research is where Clevers has been most successful in recent years and for which he also received the NWO Spinoza Prize in 2001. Clevers: 'For several decades we have known that a mutation in a single specific gene nearly always gives the starting signal for intestinal cancer. That gene, APC, is one of the genes specifically activated in stem cells.' Could that mean that stem cells are also behind intestinal cancer? Clevers group developed two types of mice to investigate that: one where the APC gene no longer worked properly in normal cells and one where it is no longer worked properly in stem cells. Mice where the gene did not work properly in normal cells developed a small clump of uncontrolled cells. That did not develop into a polyp or tumour, however, and the cells died after a few days. That was not the case for mice with the mutated stem cells. Within two weeks the intestines of these animals contained dozens of polyps. The cell division had become completely uncontrolled. 'Polyps are not directly tumours,' says Clevers. ' First the cells need to go through several other mutations before a polyp becomes really malignant. However it was clear that stem cells form the basis of intestinal cancer.'

Cells in colour

This knowledge has made it increasingly easier to investigate cancer in the lab. Last summer, together with several other institutes, Clevers managed to solve a long-standing question in cancer medicine. Until recently, it was not clear whether all cells in a tumour are equally malignant or whether just a few cells are the real culprits and cause the tumours to develop and spread. Once again Clevers' group had to use mice to solve this problem. They developed mice in which different types of cancer cells could take on different colours. Under a microscope, they could then follow exactly which cells caused the tumour growth. The colour analysis revealed that just a few cells were responsible, in most tumours three or four: these cells were called cancer stem cells. The other 'normal' cancer cells divided, but they and their descendants quickly died. The discovery is a breakthrough for cancer treatment. New drugs should be targeted at the cancer stem cells. Destroying these will stop further tumour growth cure the patient of cancer. Many small companies are now trying to capitalise on this discovery.

Lung and other organs follow intestine

After more than 20 years of hard work on a single type of cell it would seem that many of
Clevers' research results are finding their way to hospitals and companies. His efforts are now paying off. The Hubrecht Institute is trying to extend the successes it has had with intestines to the culturing of other organs. Clevers points to a petri dish next to the one in which the intestine is growing. 'Here we are busy growing pieces of lung,' he says. And under the microscope the lung structures are clearly visible. We can certainly expect more results from the Hubrecht Institute in the news. ■

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! FURTHER INFORMATION

www.hubrecht.eu: site of the Hubrecht Institute with, for example, animations of self-development in intestine.

Mice take a trip

We do not do research into the intestines and intestinal cancer by experimenting on people. Science uses an 'animal model' for such work, in this case mice. These are small and inexpensive and their development is pretty similar to that of people. When Hans Clevers started his research scarcely any animal models were available and so his lab had to develop all of them. Now the laboratory has dozens of mice models. Some of these mice miss a gene, whereas others have genes linked to a colour. With the first group, scientists can investigate what a certain gene does and what happens if the gene works less well. The second group can be used to find out when and where a certain type of gene is activated or to follow the development of tumours. The mice models have become famous over the years. Many research groups that do research into the intestines, stem cells or cancer come knocking at the door in Utrecht to ask if they may use the mice models. Clevers' mice fly throughout the world. Descendants can now be found in laboratories in Asia, America and even Africa. Only when the research on rodents has yielded its fruits will the step to humans be made.

Chaos. Sorted

The NWO Spinoza Prize is the highest award in Dutch science. The winners receive 2.5 million euros that they can use for research of their choice. Ieke Moerdijk, professor of mathematics at Radboud University Nijmegen, is one of the four winners from 2012.

TEXT: ANTJE VELD

What did you want to be when you were younger?

'At primary school I wanted to be an architect. At high school I wanted to go to the Sports Academy. But my father told me I would then be trained to become a sports teacher and there were plenty of those. So I changed my mind and chose mathematics.'

And what did you ultimately become with this?

'I am a professor of mathematics. I give lectures to students and do research. My discipline is topology, a sort of abstract modern geometry. It lies at the heart of mathematics. Many other mathematical disciplines, such as algebra or analysis, make use of topology. It is the study of spatial shapes in the most abstract sense of the word. It can be in two, three or four dimensions. You probably find it hard to imagine four dimensions, but topology studies objects with an infinite number of dimensions.'

How does that work?

'For example, by describing different shapes in three-dimensional space as a single entity or studying how one shape transforms into another. That entire system also has its own geometry.'

How did you win the Spinoza Prize with that?

'A few things caught people's attention, like developing a theory about the algebra of sets with a colleague from Montreal. Nobody had done that before. I have also made a link between topology and modern logic—two very different subjects. The link was not so obvious. I recently worked on a theory about the interplay between topology and algebra, with two French colleagues. At Harvard they are working on a competing theory, which feels like a contest. Mathematics is sensitive to trends and social interactions. Such a theory must be picked up by PhD students who can test it. Thanks to the Spinoza Prize, and the extra attention my work has received I can attract talented young people from abroad. They now want to come to the Netherlands.'

Is the Netherlands a good country for mathematics?

'The Netherlands is an educated country with outstanding mathematicians. It is also a small country. Nijmegen has about 15 tenured staff. Utrecht University and the University of Amsterdam have a staff of just over 20 people. In comparison, a mathematics institute at a provincial French university in Lille or Nice has a tenured staff of more than 100 people. That difference is a problem of course.'

Where does that difference come from?

'It is partly because the Netherlands invests little money in mathematics and partly due to how our university education is organised. In America, you must follow mathematics courses for all degree subjects and all of those are given by mathematics staff. In the Netherlands, we only give lectures to our own students, physics students and the odd biologist or chemist. In France and Germany the training to become a high school mathematics teacher is linked to the universities. In the Netherlands, that link was broken several years ago and that training has now become a course at universities of applied sciences. This means fewer university staff are needed to train mathema-tics teachers and there are also fewer university trained mathematics teachers who can inspire high school pupils to go and study mathematics. Unless you have experienced it yourself you cannot fully convey what a fantastic subject it is.'

Why is mathematics so fantastic?

'Mathematics is far more than just solving sums. It is mainly about discovering definitions and concepts we can use to create order in the chaos that surrounds us. I think that mathematics is inherent to the human existence. We try to understand the world around us in terms of structures and patterns. That is mathematics in its purest form. I gain enormous pleasure from trying to explain the beauty of something as clearly as possible without any twists and turns.'

Why is mathematics so important?

'Mathematics is underestimated. You find it everywhere in every piece of equipment. It is in your SatNav, in any computer and in the storage of fingerprints. Google uses it and we need it to explain natural phenomena. You also need a high level of mathematics to find new technological applications or to improve existing technologies.'

What do you still dream of?

'Completing the theory that I am working on with my French colleagues. Once that is finished I would like to write a book about it. I will use part of the Spinoza Prize for that. I also want to contribute to Radboud University Nijmegen, acquiring a stronger reputation in my discipline in the coming decades. For example, by inviting top mathematicians to give guest lectures and by attracting more talented people who will stay here for a long period of time.' ■

Biography Ieke Moerdijk

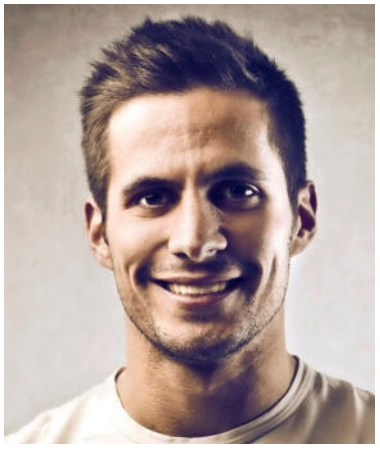
1958 Born in Veenendaal
1976 Pre-university education Comenius College, Hilversum
1981 Degree in Philosophy, cum laude, from the University of Amsterdam
1982 Degree in Mathematics, cum laude, from the University of Amsterdam
1985 PhD, cum laude, on the links between mathematical logic and topology, University of Amsterdam
1996 Professor of Topology, Utrecht University
2011 Professor of Algebra and Topology, Radboud University Nijmegen

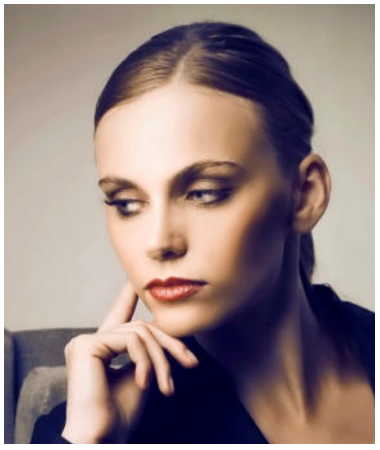
Emotions are not per se irrational

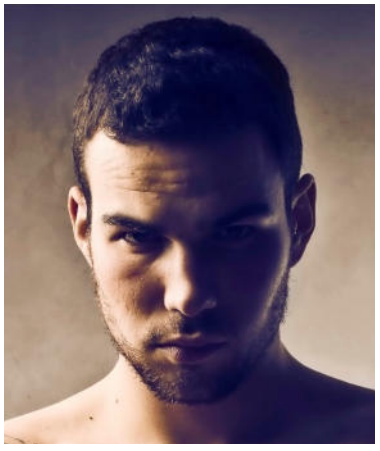
Social lubricant

Emotions have had a bad name for a long time. They were supposed to get in the way of wise decisions. Nonsense, according to professor of psychology Gerben van Kleef. Emotions are in fact a useful social lubricant.

TEXT: ASHA TEN BROEKE





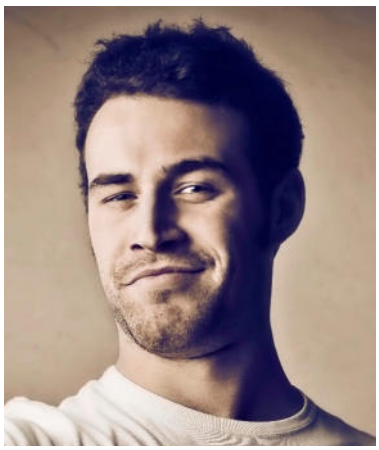


For a long time emotions had a bad name. They were considered troublesome and got in the way if you needed to make a wise decision. The Greek philosopher Plato once described them as 'strings that continually pull us in opposite directions'. He believed that reason had to suppress emotions as otherwise you would certainly make rash and wrong decisions. Our everyday language still reveals the link between emotional and irrational: emotions 'overwhelm' us, we are 'distraught' from sorrow, 'blinded' by anger and 'paralysed' by fear. But Gerben van Kleef, a young professor of social psychology at the University of Amsterdam has a completely different view of emotions. Emotions are in fact incredibly important. They give us the information we need about the world and the people we come across. Van Kleef investigated this and presented his findings in the book *Op het Gevoel* [Running with your feelings]. He urges us to embrace our emotions as social advisers.

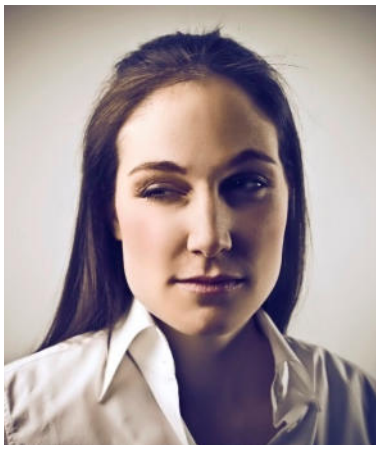
Face provides us with information

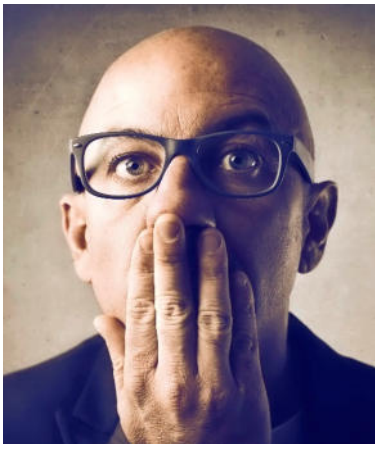
'Many people think emotions belong to the individual, and that only the individual feels and experiences these. But emotions can also facilitate social interactions,' says Van Kleef in his office in the centre of Amsterdam. 'That is what they have evolved to do. Our faces are full of muscles that show other people which emotions we are experiencing. They are there for a good reason. People are also very good at reading those muscles to work out how somebody is feeling or what somebody thinks of a given situation. That helps us to respond adequately.' That ability to read and respond to somebody's emotions is a skill we possess as babies. In his book, Van Kleef describes an experiment in which babies aged 9 to 12 months were placed on a 'high table' ▶



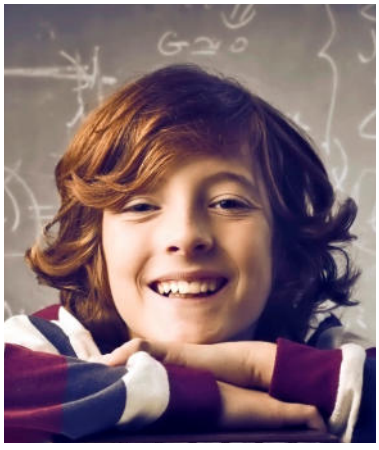









Emotions are infectious: you simply cannot resist them

with a thick glass plate. A firm surface was visible immediately under this plate and so the baby felt safe. An attractive toy was placed at the end of the plate and the baby crawled over the glass towards it. Then the baby encountered a so-called 'visual cliff'. Although the glass plate continued further until the toy the baby saw right down into the chasm. That made the baby hesitate: can I cross this safely? At such a moment a baby looks to the face of its father or mother who is strategically positioned behind the toy. If the parent looks happy, the baby dares to cross over the cliff. But if the parent looks worried, the baby refuses to go any further. The baby reads what it must do from the emotions on its mother's or father's face.

Emotion is a herd behaviour

Emotions also help social interaction in another way: they are infectious. 'Emotional infection happens when we automatically and unconsciously adopt the emotions of others,' says Van Kleef. 'Just like now: you are smiling and I involuntarily smile as well. That is because all herd animals, including people, have an innate tendency to imitate each other. For example, when one buffalo sees a lion and runs away the rest automatically follow whether they have seen the lion or not. We imitate. And if I imitate your smile, my brain registers the muscles in my face making a laughing movement and I also feel happier. Not only is that a pleasant experience for me at that moment, but it helps me to understand what somebody is experiencing. Through imitation and infection you genuinely feel it as well.' How much our facial muscles influence our emotions is apparent from the classic experiment Van Kleef describes in his book. Half the study subjects had to hold a pen horizontally between their tightly clamped lips and keep it there. They then watched funny cartoons. The other half saw the same films but clamped the pen between their teeth. This group found the cartoons far funnier than the first group. The reason: with a pen between your teeth you can still smile at the films, but with a pen between your lips you cannot.

Infect your loved one

Emotional infection is not only useful during a conversation, but can also help longer term social interactions. In his book, Van Kleef writes about an American study into the infection in couples. In the lab, couples told each other about the positive and negative experiences that they had just had. After doing this they both received a questionnaire on which they could register their emotions. The researchers' underlying idea was: the more these

Anger for sale

Sometimes it pays to be angry. Experiments by psychologist Gerben van Kleef revealed that a bit of carefully positioned anger during negotiations can be to your advantage. Study subjects were given the task of selling mobile phones via the computer and this involved negotiating the price, service contract and guarantee. During these negotiations the study subjects were found to give in sooner if the seller responded angrily. The reason: from the anger they deduced that the seller had a lower offer in mind.

Guus Hiddink's success is partly attributable to his ability to empathise with other cultures.

Our tendency to imitate is inherent to our nature. Just like buffaloes: if one runs they all run.

Gems of emotional wisdom

Emotions span history of course. This is what some philosophers and scientists have said about emotions.

- **Plato (about 427 - 347 BC):** reason must come before emotions as otherwise we will take rash decisions.
- **Aristotle (384 - 322 BC):** emotions influence our ability to assess things but they are vital if you want to convince somebody about something.
- **Seneca (4 BC - 65 AD):** emotions only bring misfortune. Happiness can be found in indifference.
- **René Descartes (1596 - 1650):** emotions cloud the mind and must be subject to reason.
- **Immanuel Kant (1724 - 1804):** decisions must be a rational consideration. Emotions can throw a spanner in the works.
- **Charles Darwin (1809 - 1882):** emotions have evolved because they are useful for the continued existence of the species.
- **Friedriech Nietzsche (1844 - 1900):** emotions are a source of energy and can lead to great exploits.

SOURCE: *OP HET GEVOEL* [RUNNING WITH YOUR FEELINGS] BY GERBEN VAN KLEEF

emotions agree with each other the more infection has taken place. And the more infection, the more you empathise with each other, which in turn is good for the quality of the relationship. To test that, the couples returned to the lab six months later and told each other about the positive and negative events and their emotions were subsequently measured. The researchers saw that since the first visit the partners' emotions had become more synchronised. The longer couples have been together the more they infect each other with their emotions and more infection led to partners being happier about the relationship.

Hiddink is flexible

People differ in their ability to adopt, read and show emotions, says Van Kleef. Some people have a higher emotional intelligence than others. 'Somebody with a high emotional intelligence can suppress or accentuate their emotions at the right moment,' he says. 'It is all about knowing when it is useful to show or hide you emotions. That is very culture-specific. In the United States anger is sometimes useful, as then you appear to be assertive and that is important. In the courteous, introverted Japanese culture, however, showing anger will almost never give you an advantage.' Van Kleef gives football coach Guus Hiddink as an example. 'He has achieved success with teams from very different cultures: South Korea, Russia and Australia. This shows he is very good at switching between cultures. What makes a football coach so interesting is that they are one of the few types of leader who we can occasionally see at work, for example when cameras are on the sidelines during a training session. From what I see on television, Hiddink is extremely flexible in how and when he shows his emotions.'

Faking is not allowed

You must show genuine emotions, emphasises Van Kleef. Sometimes that goes wrong like the response Dutch Prime Minister Mark Rutte showed after the PVV party had walked away from negotiations about cutbacks in the spring of 2012. 'Rutte always does an ideal son-in-law act. He is always a happy and jovial. Yet he also did that when the negotiations failed and that was not credible. People see straight through such faked emotions and do not easily accept such a show.' This was underlined by an experiment Van Kleef ▶

False emotions are not honoured

conducted with several colleagues. They brought in a professional actor who pretended that he was going to buy a second-hand car and became angry about the ridiculously high asking price. The first time the actor made sure that he felt genuine anger: just before filming he thought back to a situation that had made him very angry. The second time he did not do that but put on an angry face without genuinely feeling the underlying emotion. Subsequently Van Kleef invited to study subjects to place themselves in the role of the car seller: they had to imagine that they were going to sell a car to the man in the film. The study subjects who saw the film containing the genuine anger derived from his anger that he really did not want to pay a lot for the car and asked slightly more than 3000 dollars. The study subjects who saw the film with the fake anger asked about 3200 dollars for the car. They could see that the emotion was not real and therefore thought: stuff you.

Emotions add something

You can clearly see that Van Kleef is enthusiastic about his research. In his office he rapidly talks with a broad grin about the insights he has acquired in recent years. He is living at the right time he admits. Now is a good moment to be passionate about emotions. 'I think that emotions are growing in importance. Society is calling for more emotion. I think that this also has a clear purpose, as it is very useful to know how somebody feels about something. Revealing far more than a slick talk, emotions add something genuine.' ■

redactie@quest.nl

Emotion m/f

'Women's emotions are often viewed differently from those of men,' says professor of social psychology Gerben van Kleef. 'In men we accept and expect the harder emotions such as anger and aggression, whereas in women we expect nurturing and empathy. Anger is simply not done for women.' An example from Van Kleef's book *Op het gevoel* is Bill and Hillary Clinton. Research has shown that the anger Bill exhibited as president when he was accused of extramarital sex with Monica Lewinsky gained him support. Yet when Hillary as Secretary of State responded agitatedly to the student who asked what her then no longer politically active husband Bill thought of a trade agreement, she received the unsympathetic label '*mad as hell*'.

An angry Hillary or an angry Bill carries a different emotional value.

Mark Rutte's jovial image often works to his advantage, but not when the Cabinet has just fallen.

BEATRICE DE GRAAF (36), Professor of Conflict and Security in Historical Perspective at Leiden University, received a Vidi grant in 2008.

Safe idea

NWO funds talented scientists with an innovative research plan. The Veni grant is for researchers who have recently gained their PhD and is worth up to 250,000 euros. The Vidi grant is for more experienced scientists and is worth 800,000 euros. The Vici is for senior scientists and worth 1.5 million euros.

Why exactly were you chosen?

'A miracle, good luck, hard work, and the fact that I have a long track record in the history of security. I also highlight the innovative character of my proposal, which is hard for historians as we distinguish ourselves more by our research subject and less by new methods. Yet for these type of grants, the methodological innovation is very important. I appropriated some social scientist methodology for my research on 'securitization', in itself a combination of political science and linguistics. I reconstruct, identify and analyse how historical cases of terrorism and counterterrorism were 'securitized', how they were put on the public and political agenda, conveyed in the media and perceived and received by different target audiences in society.'

How are you using the grant?

The Vidi grant made it possible for me to build a solid, fundamental research base, Spin-offs include publishing my book Evaluating Counterterrorism Performance in 2011. In the book, I show how governmental security measures – by the police, the judicial apparatus, the intelligence services and "politics" at large – in their framing and performance affect the cause of terrorist events. Terrorism is theatre, as notable terrorism researchers stated in the past. Counterterrorism also contributes to this theatre: mitigating it or expanding it. That is hard to control, as extra attention only reinforces the anxiety. There is a brilliant sketch from John Cleese as an airline pilot who announces: 'Ladies and gentlemen, the right engine is not on fire at the moment.' Which of course immediately sows panic. The same applies to security policy. Counterterrorism is highly performative. Speaking security has severe consequences. I try to analyse what these consequences are.'

How did you end up in this line of work?

'I grew up in Putten, where in the Second World War 600 men were taken away and executed in Germany, including relatives of my father. My father, a history teacher, set up a foundation to remember this historical tragedy. Through this foundation he was in touch with people from the German villages where those men from Putten lie buried. They visited us in the Netherlands. So I developed a fascination for war and violence at an early age. Although I initially did not want to follow in the footsteps of my father and started to study phsyics and German, I very soon swapped the physics for history. And never regretted that'

What would you still like to investigate?

'I find it particularly interesting to view new developments within the security and conflict field in their historical perspective. I am drafting a series of new research proposals and carrying out projects ranging from 'Terrorists on Trial: the courtroom as a stage', to research into reintegration and deradicalisation of former terrorist convicts. My main focus, however, is the study into the beginnings of the Dutch centralized security politics around 1813, with the start of the Kingdom of the Netherlands. How did they perceive and do security back then?' ■

Vital aid for research

Public benefit

NWO makes funds available for high-quality facilities that are accessible to researchers from the Netherlands and abroad. That could be a supercomputer, a unique microscope or a special database. Such facilities are often unaffordable for a single university and are invaluable to science. These 11 facilities could be established thanks to NWO.

TEXT: AMANDA VERDONK & MARIKEN BOERSMA

Access to research

Some types of research require equipment that a single university or institute cannot afford. In that case researchers can submit a proposal to fund the purchase or development of this high-quality equipment or facility. If the proposal is awarded funding, then researchers from the Netherlands and abroad can make use of the facility concerned. NWO can also mediate on the behalf of Dutch scientists who want to do research at a foreign location. In this case, the organisation pays for the use of those facilities.

CLIO-INFRA
Unfair world unravelled

What is it? A website with figures about the world economy from the past 500 years.
Why is it so special? The world is full of inequality. For example, most Russians are richer than Africans. We live in stone houses, but many Vietnamese live in rickety huts. To understand why, we need to go back a long way. Researchers want to do this for 150 countries, over 500 years.
Research? There are many theories about how inequality arises, but hard evidence is lacking. With this database, researchers hope to test their theories. Economic historian Jan Luiten van Zanden from Utrecht University is collecting the data, together with an international network of about 200 experts. There are hundreds of factors that can explain the inequality in the world. Examples are income, education and life expectancy. But also people's height and how good they are at doing maths. That says something about their health and educational level. Prosperous people are generally healthier and better educated than poor people. Finding the data is difficult in some countries like, for example, Africa and North Korea. Van Zanden is particularly pleased that China and

Russia have recently opened their archives. He is fasinated by how the economy is driven by balances of power. Does the head of state act as a tyrant who does not tolerate criticism? Or does he listen to the people and is accountable for his deeds? 'There are many indications that transparency and democracy are good for economic growth. It would be great if our research could give an answer to that.' The website must be completed by 2014. Then researchers can look up a wide range of pressing issues in the database.

V-gait
Virtual rehabilitation

What is it? A treadmill in a virtual walking landscape like a wood.
Why is it so special? You walk in a changing environment. The path becomes narrower or a large stone is suddenly in the way. Our eyes see these changes and pass them on to the brain. This adjusts our movement where necessary. Because the environment passes by you, the V-gait realistically simulates a walk through the woods. The treadmill can even move to simulate an obstacle lying on the path. It provides useful practice for people who have walking problems. Their movements are accurately recorded with 50 markers while 32 EMG sensors measure the electrical activity of the muscles.
Research? Jaap Harlaar, biomedical engineer at the Department of Rehabilitation Medicine, VU Medical Centre in Amsterdam: 'On the treadmill, we first want to investigate children with cerebral palsy (CP). CP is the result of brain damage that occurs around birth, and the children subsequently have difficulty moving. The exact cause differs per child. A child with CP might walk poorly due to spasticity in his leg muscles. For another child with CP, the control signals from the brain can be disrupted, or they might have shortened muscles. On the V-gait we can apply a distraction,like a descent, during the walk. Using sensors, we can measure how this influences the movement. By applying targeted perturbations we hope to discover the exact cause of the pathological walking pattern. Our first study will compare the V-gait analysis with our old research set up. That is an overground course of limited length and similar recordings. We want to know what meaningful information perturbations of the walking surface and visual feedback on the V-gait can be concluded. Harlaar hopes that the treadmill will lead to better treatments for people with movement problems.

The brain bank already has 3500 brains

Each year 100 to 120 autopsies are performed.

The Netherlands Brain Bank
Brains to order

What is it? A storage place for brains.
Why is it so special? Do you feel you are being followed and that you are the victim of a conspiracy? Or do you think you are God's special ambassador? If you have ever experienced these feelings then you might be schizophrenic. Scientists do not know exactly what goes wrong in the brains of people with this mental disorder. The same applies to other brain disorders like dementia, depression, autism or post-traumatic stress disorder. The Netherlands Brain Bank has been collecting brain tissue since 1985. Scientists use it for research into these disorders.
Research? Inge Huitinga from the Netherlands Institute for Neuroscience in Amsterdam regularly recruits donors with her colleagues through patient associations. If a donor dies, an undertaker quickly picks up the deceased and brings the body to the VU Medical Center in Amsterdam. There, four specialists take care of the patient. They open up the skull and remove and weigh the brain, note important characteristics and take photos. The brain is subsequently cut into about 100 pieces. Pieces are frozen or placed in formaldehyde and conserved in paraffin. Sometimes the researchers come and pick up the tissue immediately. The deceased leaves the hospital about 10 hours after his or her last breath. After diagnostic staining, the doctors also examine the brain under the microscope to identify the brain disease that person had. For example, which type of dementia. Researchers worldwide apply for the tissue at the Netherlands Brain Bank. Huitinga: 'Most brain researchers only look at rats and mice, but brain disorders in people are still a completely unknown area. You can frighten a mouse, but you cannot make it suicidal. And a rat does not become demented by itself. Understanding what can go wrong in the human brain is important.' Ultimately this knowledge must lead to a more effective treatment of brain and psychiatric disorders.

Nederlab
Access to a giant library

What is it? A search engine and a laboratory to study and analyze Dutch digital texts since about 800 AD.
Why is it so special? When did the word 'democracy' first appear in the Dutch language and did this have a positive or a negative connotation? What is the origin of the word 'bakkeleien'? Nederlab will allow you to investigate such things in detail. Computer access to old books, reports, poems and plays is already possible. Searching files from all libraries with a single click, however, is still not available. Nederlab can do that, which is a goldmine for researchers
Research? Historical linguist Nicoline van der Sijs, from the Meertens Institute in Amsterdam, will work with research institutes and libraries to produce better search programs, and to adapt search programs and software for text analysis to historical texts. The variety of spelling and word forms in historical texts greatly impedes text research. Personally, Van der Sijs would like to use Nederlab to find out more about the development of standard Dutch, as we speak it now. 'The Statenvertaling [authorised translation] of the Bible was important for the formation of standard Dutch. People say it is written in the language used when it was published (17th century, ed.). I think that the Biblical text, however, was already old-fashioned. I would like to compare the language from the Statenvertaling with other documents from that period. With letters, for example, because these lie close to the spoken language.' From 2018 onwards, researchers will be able to use Nederlab for large-scale research over a long period of time. We can learn, for example, how language and culture change through wars. Or through migrants, who often devise new words like 'bakkeleien', which comes from the Malaysian word 'berkelahi'.

The four containers are named after four ships of a fleet that were seeking a trade route back in 1598: Annunciation, Faith, Hope and Love. The Annunciation drifted southwards and captain Dirck Gerrritsz saw mountains covered with snow: the Southern Shetland Islands near Antarctica.

Dutch lab on the South Pole
Research in sea containers

What is this? Four mobile laboratories in sea containers.
Why is this so special? In January 2013, NWO opened the first Dutch laboratory on Antarctica. The Dutch laboratories are located on a British base. That is very efficient for both sides, the British hosts and the Dutch guests, and minimises the damage caused to the Antarctic nature. The Dutch laboratory building is the home of four sea containers that have been constructed as mobile laboratories. These are easy to transport. On the inside, the containers are fitted with high-tech measurement instruments to investigate the seawater. The laboratories were designed by the NIOZ Royal Netherlands Institute for Sea Research.
Research? Oceanographer Hein de Baar and other NWO researchers have worked the first season in the container labs and everything functioned very well. In the ice-cold water, various aspects of the sea can be investigated. Notably the algae and viruses present and several greenhouse gases that the algae either use or excrete. De Baar studies trace metals: very small quantities of metal that are dissolved in the water. These dissolved trace metals end up in the water when the ice grinds over the Antarctic landmass. The ice cap is melting and retreating, however, and so less dissolved metals enter into the sea. That is a problem for all organisms, starting with the algae that need some of the trace metals to grow. The researchers have discovered that at the end of the summer season, around February, the algal bloom collapses. All of the dissolved trace metals might have been used by then. De Baar: 'Algae form the base of the food chain. If they are no longer present then the effect of this is felt throughout the entire food web up to the whales and penguins.' In order to collect seawater the oceanographers lower a cable with sampler bottles attached into the water. The bottles fill up with seawater. In the lab, the researchers make measurements and from this they also know whether the quality of the samples is good enough. Seawater samples are also taken home to be further studied in the Netherlands. De Baar hopes to find out how the Antarctic seawater and the algae are responding to climate change.

Pelagia
Searching for sea monsters

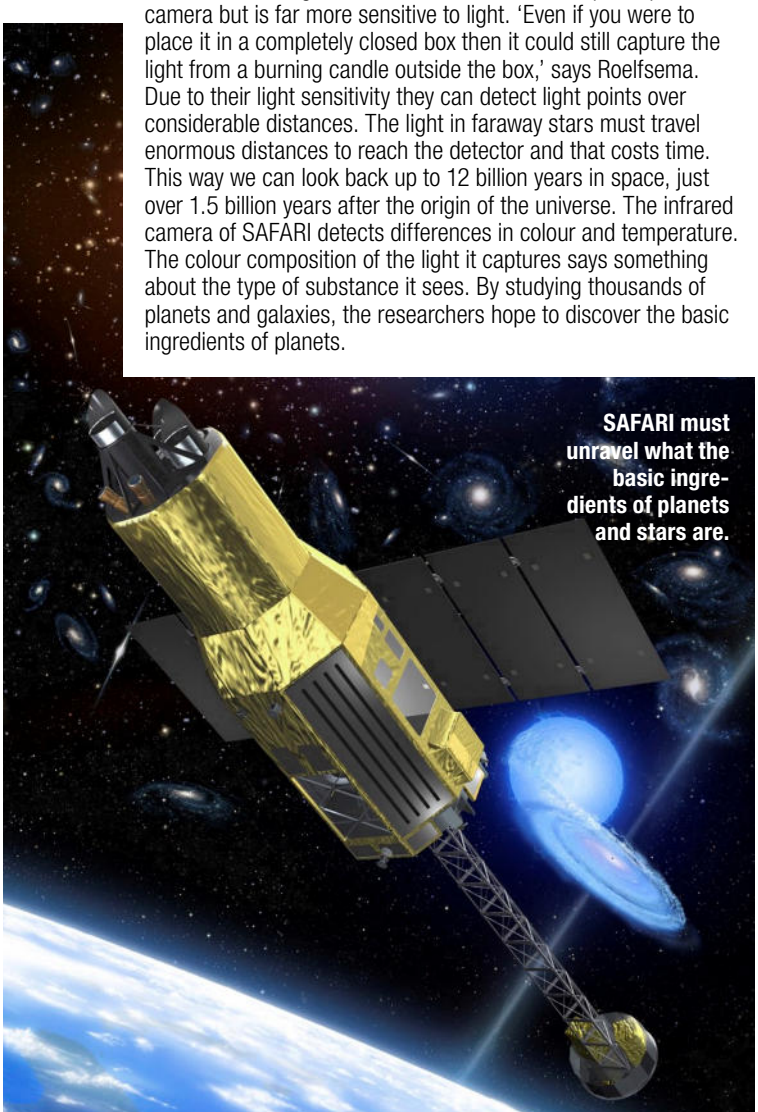
What is it? The research vessel Pelagia.
Why is it so special? It is sometimes said we know more about the moon than about our own oceans. Research kilometres below sea level is a hazardous task. At that depth, measurement equipment not carefully packaged can collapse under the high pressure. The research vessel Pelagia has been rummaging around the world's seas for the past 20 years, in areas not previously investigated. It is hauling a wealth of new knowledge to the surface, for example, about algae, plankton and bacteria.
Research? Oceanographer Hans van Haren from the NIOZ Royal Netherlands Institute for Sea Research and his colleagues are working on the Pelagia, a floating laboratory. They are studying the temperature, salinity, turbidity and quantity of light in the sea. On a steel cable several kilometres long, 20 litre-sized bottles plunge into the deep. At different depths they take a sample of seawater. The cable itself also contains electronic measuring equipment. 'The ocean is constantly moving and so long-term measurements are useful too,' says Van Haren. So the Pelagia regularly deposits a similar cable with measurement equipment, which is then attached to an anchor weight. The cable sometimes remains in place for two years. This allows the researchers to see how the sea changes. Van Haren investigates the waves, currents and turbulence in the deep sea. Turbulence develops when water collides with the land, for example, against the coast or against an undersea mountain. That sloshing causes substances on the floor, such as dead plankton, to rise up. They mix with the seawater so that fish can swallow them. The research on the Pelagia is aimed at gaining new knowledge about the oceans.

Doing research in the deep sea is not easy. The vessel Pelagia has been pioneering on the oceans for decades.

SAFARI can detect the basic materials for a planet

SAFARI
Searching for ancient stars

What is it? A telescope with a supercamera that searches for old galaxies. The instrument is part of the Japanese space telescope SPICA, which will be launched in 2022.
Why is it so special? How do planets, like earth, evolve? And galaxies like 'our' Milky Way? SAFARI can provide an answer to this. Its camera has very sensitive detectors that can capture the radiation from particles and gases from earlier time periods. It can also detect the basic ingredients for the creation of a planet: minerals and water. Researchers hope that SAFARI will help them discover more about the evolution and early developmental history of galaxies.
Research? Peter Roelfsema from space research institute SRON in Groningen is principal investigator of an international team of astronomers. They are working on detectors that can see the tiniest bit of light. Such a detector is like a chip in a photo camera but is far more sensitive to light. 'Even if you were to place it in a completely closed box then it could still capture the light from a burning candle outside the box,' says Roelfsema. Due to their light sensitivity they can detect light points over considerable distances. The light in faraway stars must travel enormous distances to reach the detector and that costs time. This way we can look back up to 12 billion years in space, just over 1.5 billion years after the origin of the universe. The infrared camera of SAFARI detects differences in colour and temperature. The colour composition of the light it captures says something about the type of substance it sees. By studying thousands of planets and galaxies, the researchers hope to discover the basic ingredients of planets.



SAFARI must unravel what the basic ingredients of planets and stars are.

Laser-Multipatch electrophysiological set-up
Neurons imaged

What is it? A laser that can stimulate individual brain cells (neurones) and then lets you measure how this stimulus is transmitted to the surrounding cells.
Why is it so special? 'With the new device we can stimulate a single neurone in a slice of brain tissue and see how this transmits a signal,' says molecular neurobiologist Ype Elgersma from the Erasmus Medical Center in Rotterdam. 'And we can also see what happens if that transmission is disrupted, as is the case for people with brain disorders. Previously we could only stimulate a group of neurones.'
Research? Various proteins ensure that the transfer of information between brain cells occurs correctly. If one of the proteins is missing then we develop learning and memory problems, like people with tuberous sclerosis complex (TSC). Elgersma: 'Due to a genetic defect, they lack a crucial protein in the brain. That results in intellectual disabilities and epilepsy at a young age.' Elgersma will use the new equipment to do research into such conditions. 'We can culture brain slices (from mice, ed.) with the same genetic defect and then measure what goes wrong during the information transfer between neurones.' With the help of this type of research, Elgersma has found a medicine to treat TSC. In a TSC mouse model this drug can replace the missing protein. 'For example, in TSC mice we can now completely cure epilepsy. And I am curious to discover if that will work as well in people. The new equipment not only allows us to speed up the research but to make more accurate measurements as well,' says Elgersma. Using this equipment he hopes to obtain more insight into intellectual disabilities and possible medicines against these.

Ultrafast spectroscopy lab
Superstroboscope

What is it? A laboratory set-up that transmits ultrashort laser pulses like a sort of stroboscope.
Why is it so special? All materials are comprised of molecules, which are not stationary but are constantly moving. Special techniques are needed to study these ultrafast movements. Yves Rezus and Huib Bakker from the Institute for Atomic and Molecular Physics (AMOLF) in Amsterdam explain: 'We study how molecules behave in a solution, for example how quickly they rotate. To do this we illuminate a solution with two ultrashort infrared pulses. There is a short time delay between the two pulses. The first pulse causes some of the molecules to vibrate and with the second pulse we determine to what extent these molecules have rotated. By repeating the experiment with different time intervals we can form a picture of the movements.'
Research? Rezus is now constructing the latest set-up with the infrared stroboscope. He will use it to study the movements of biomolecules (such as proteins, which form the basis of life processes). 'In particular, I want to study lactose permease, a protein which pumps sugar in cells. I want to know how the molecule's movement is related to its biological function. I also want to do the same for elastin, a protein which makes our veins elastic. Our aim is to discover exactly how these proteins work.' The research with the 'ultrafast spectroscopy lab' is fundamental research that will probably not yield an application or treatment within five years. Bakker: 'But it might well do that within 30 years. The discovery of the laser, about 50 years ago, was also the result of fundamental research. Now everybody has several of them in their homes.'

Jan-Pieter Abrahams: 'Using this equipment it is possible to see how a virus attaches itself to a cell.'

NeCEN Electron microscope
Great in the smallest possible

What is it? The most powerful electron microscope in the world. Since October 2011 it has been located at the NeCEN research centre in Leiden but it was jointly realised by ten universities and research institutes.
Why is it so special? It is one of the five electron microscopes in the world that can make a protein molecule visible at the atomic level. Molecular biologist Jan-Pieter Abrahams from Leiden University: 'To study the details of a protein with X-ray crystallography (the current method) we must first of all let the protein crystallise. However, many proteins are difficult to crystallise and we still cannot visualise their atomic details directly. Using the new supermicroscope we can visualise a protein directly in detail. Like the proteins involved in the development of cancer or those found in cell membranes and to which medicines bind. With this device we can also see how and where a virus attaches to a cell. That is a major difference with traditional microscopes with which you can see a cell and some of its internal structure, but not any further details.'
Research? The supermicroscope has many applications and is mainly used for research into diseases and the effect of medicines. 'With the microscope we can understand body processes and diseases far better. Scientists, but also companies, can rent time on the microscope. Also with the arrival of the supermicroscope a new branch of science has developed. The device produces a large number of detailed images. How do you select the most relevant of these? 'We need to come up with mathematical methods to read these databases of information,' says Abrahams.

Laser-Multipatch electrophysiological set-up
Neurons imaged

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How do you make a particle that is its own antiparticle?

Making Majoranas

They are both professors of physics and have known each other for about 25 years. Carlo Beenakker beavers away at Leiden University on the theory and Leo Kouwenhoven develops experiments at Delft University of Technology. In 2012, that led to a strange result: the Majorana particle that possibly does not exist.

TEXT: MARC KOENEN / PHOTO: SAM RENTMEESTER

Leo Kouwenhoven (r) with Kun Zuo and Vincent Mourik, who are part of Kouwenhoven's group in Delft.

'The first time I mentioned it, you did not know about it,' says Carlo Beenakker. 'No,' answers Leo Kouwenhoven. 'I thought you had said 'marijuana particle'. Many other people think that when they hear it for the first time.' Perhaps that is understandable. For many people the particle is just as confusing as cannabis. 'The Majorana particle is a strange thing,' admits Beenakker. It leads a very uncertain existence: if it is there it should destroy itself. It emerged in 1937 in the brain of the Italian physicist Ettore Majorana, when he was doing calculations about matter and antimatter. Difficult stuff, but what it boils down to is that for every particle there is an antiparticle. If they meet each other a flash of energy is released and then they cease to exist.

Hard to imagine? Yes, but it is possible. For example, the electron, the negatively charged particle that enables our electrical equipment to work, has a positively charged antiparticle called a positron that does exist. You can make positrons visible in an experiment. Majorana could not do that with the particle from his calculations. Freely translated the outcome means: 'Particles which are their own antiparticles exist.' Therefore, particles that destroy themselves and each other. Matter and antimatter in a single entity. Confusing? Not in Delft. There Kouwenhoven's research group has made such Majorana particles, based on the theoretical work of people like Carlo Beenakker.

How did the collaboration start? Did you sit down together and plough through the article Majorana wrote about the particle in 1937?

Kouwenhoven (K): 'No, I have not read it. I took a quick look at it, but it is not a sort of Bible for this research.'

Beenakker (B): 'In 1981, somebody translated Majorana's article into English and published it in a vague Japanese journal *(Soryushiron Kenkyu, ed.)*. Not because they saw something in the article, but because some people enjoy doing that if they have nothing else to do. For example, German manuscripts of Einstein are still being translated into English. Not a lot would have happened with Majorana's article had no new discoveries been made into neutrinos (an elementary particle that really does exist, ed.). Majorana had suggested that a neutrino can be a Majorana particle, and with the new discoveries it became interesting to ▶

‘We do not know what we can do with the particles’

Microsoft is involved

If the Majorana particle is both matter and antimatter, a digital application could be on the horizon. Computers can process information offered as a series of zeros and ones. If you could package the information in a series of matter and antimatter Majorana particles then computers could be far faster still. At least that is the idea, which is why software giant Microsoft is helping to fund Kouwenhoven’s research. NWO and FOM have funded his group since 2004. Beenakker: ‘The Netherlands is pioneering this research. I hope and expect that NWO and FOM will continue to be sensitive to this.’ The problem, he says, is the Dutch government’s investment in the top sector policy to bring knowledge institutions and industry together. That costs a lot and so often little is left for new developments that arise through research. ‘We are attracting students and top researchers from abroad,’ says Kouwenhoven. ‘However funding uncertainties mean that working here is risky. I hope we can continue to maintain our lead and not rapidly lose our advantage to the United States again.’

What happened to Ettore Majorana?

If Majorana particles can spontaneously cease to exist then Ettore Majorana lived up to his name. On 26 March 1938, when he had just turned 31 years, the physicist bought a ticket for the boat from Palermo to Naples and was never seen again. Some say he committed suicide and others think he lived elsewhere under a different name. His work also disappeared from view. Majorana suggested that two previously discovered particles might be Majorana particles: the neutron and the neutrino. The neutron was soon ruled out. It is found in nearly all atomic nuclei of ordinary matter. The neutrino is a different story. For example, it is spewed out by the sun and each second, billions of these pass straight through the earth (and us) unnoticed. In recent years more properties of neutrinos have been discovered that match those of the Majorana particle. One day it might be demonstrated that the neutrino is a Majorana particle.

make a thorough theoretical analysis of the prediction.’

K: ‘But Majorana’s article is not directly relevant to our work here in Delft. It is interesting for people searching for the Majorana particle in the natural world. We are not doing that. We are making it ourselves in an experiment.’

B: ‘Of course the natural version is more beautiful. I mean, real diamonds are more expensive than artificial ones from the lab. As a theoretician, I am interested in the Majorana particle’s properties. Then you start thinking about how you can use and apply those. That is definitely not possible for neutrinos. They are too elusive to work with. But perhaps we could find a way to transfer those properties to a workable experimental set-up. I went and talked with Leo about that. I have known him since 1987. We regularly exchange students and we hold work in progress meetings together. So our groups in Leiden and Delft were already doing a lot together.’

K: ‘When Carlo started to talk about the Majorana particle I simply felt it was a strange thing. It did not grab me. But repetition helps. Carlo kept on returning to the subject. Then you start to think ‘Has that oddity got something interesting?’ Perhaps matter and antimatter that can be united into a single particle is more than just odd. What if you could do something with it? My mind kept on turning it over, but I only really got time to think it through during a sabbatical.’

B: ‘And I focussed on other research. I had plucked the easy-to-reach fruits of the Majorana particle and I went in search of a different subject. Leo did not. He has a lab. And that is completely different from what I do.’

K: ‘Upon returning from my sabbatical I wanted to design a Majorana experiment. How you do that? Apply for a grant, from NWO and FOM (Foundation for Fundamental Research on Matter, ed.), and get the right people on board. I had already started doing that during my sabbatical when I attended a beach party in Scheveningen to celebrate a PhD graduation. With a drink in your hand, it is easier to convince people you are going to do something fun. And they signed up while we were still drinking. We started in August 2010. The ideas for the experimental set-up were still rather vague. We knew that a superconductor would be part of it. But from which material? And how it should be attached to the other components? That was a matter of reasoning and experimentation and if it did not work then trying out something else.’

‘This was the prologue’

It did not even take that long. In April 2012, the scientific journal *Science* had already published the article from Kouwenhoven’s team that revealed how they made Majorana particles. Not a natural Majorana particle, but electrons that received the properties of these. In an experimental set-up just a few thousandths of a millimetre in size, they transmitted electrons via a gold contact through a wire of indium-antimony coated with a superconductor of niobium, titanium and nitrogen. If you carry out the experiment in a magnetic field at an extremely low temperature then two particles that are their own antiparticles appear in the wire. It is a pair of electrons that behave as a single entity with the characteristics of Majorana particles, says Kouwenhoven. Nice. Research finished? ‘No,’ he laughs. ‘This was just the prologue. You could say that we have made the first photo of a Majorana particle, but it is still quite blurred. It needs to be far sharper. More can be discovered about the particles and how you can use them will also become clearer. I still do not know that yet. But if you do something fundamentally new, like this research, an application usually arises as a matter of course. I am convinced of that.’ ■

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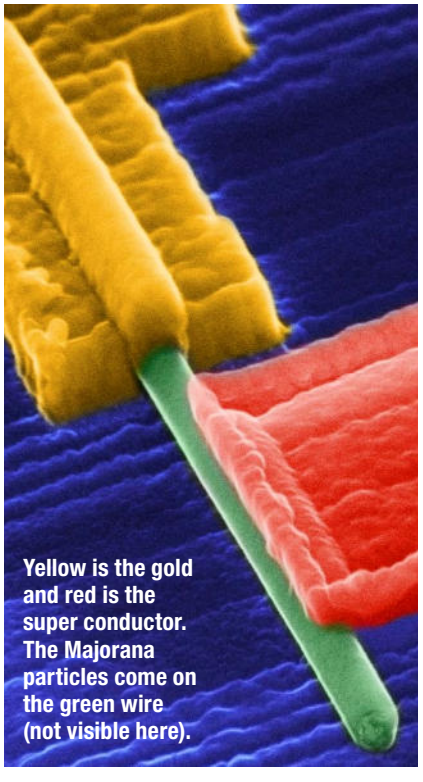


Yellow is the gold and red is the super conductor. The Majorana particles come on the green wire (not visible here).

RIEKELT HOUTKOOPER (31), AMC medical biologist, received a Rubicon grant in 2009 and a Veni grant in 2012. He went from the Netherlands to Switzerland.

How to reach 120 healthily

A Rubicon grant gives young scientists the possibility to gain research experience at an excellent foreign institute soon after acquiring their PhD.

Why exactly were you chosen?

'My research subject is popular: the relationship between ageing and metabolism. For a long time people thought it was impossible to change the ageing process in the body. Recently, however, we have discovered it can be influenced. My main focus is metabolic diseases that are very common among the elderly, such as diabetes and obesity. My proposal for a Rubicon grant focused on the characteristics of the protein sirtuine 1, which plays an important role in these diseases. However, during my research I drifted further away from that question because I came across another vitamin. NWO allows you that freedom.'

What are you using the money for?

'We have discovered that the vitamin 'nicotinamide riboside' protects laboratory mice from diabetes and obesity. Now after experiments on roundworms, whose metabolism is similar to that of people, we think it can also be used in humans. The vitamin is found, for example, in milk and in the yeast of strong beers, but the quantity is unknown. You would probably have to drink litres to obtain an effective dose.'

'Another, as yet unpublished, part of the research focuses on genes. Just like people, mice reach different ages: one becomes 18 months and another 30 months. In mice we have discovered genes that influence this. As we can test things faster on worms, we used these for the experiments. If you switch off specific genes in the worms, then thirty to sixty percent of them live longer. It is an ageing gene people also have and so it must be applicable to us as well.'

How did you end up in this line of work?

'In Amsterdam I did research into a very rare metabolic disease, the Barth syndrome. About 150 boys worldwide suffer from this. Their mitochondria, which provide the energy in cells, do not work well. After my PhD, I wanted to continue working on these mitochondria, but then for more common diseases. Thanks to the Rubicon grant I could do the research into obesity and diabetes in Switzerland. Now I am back in Amsterdam again and I am combining research into rare diseases and more common diseases.'

What would you still like to investigate?

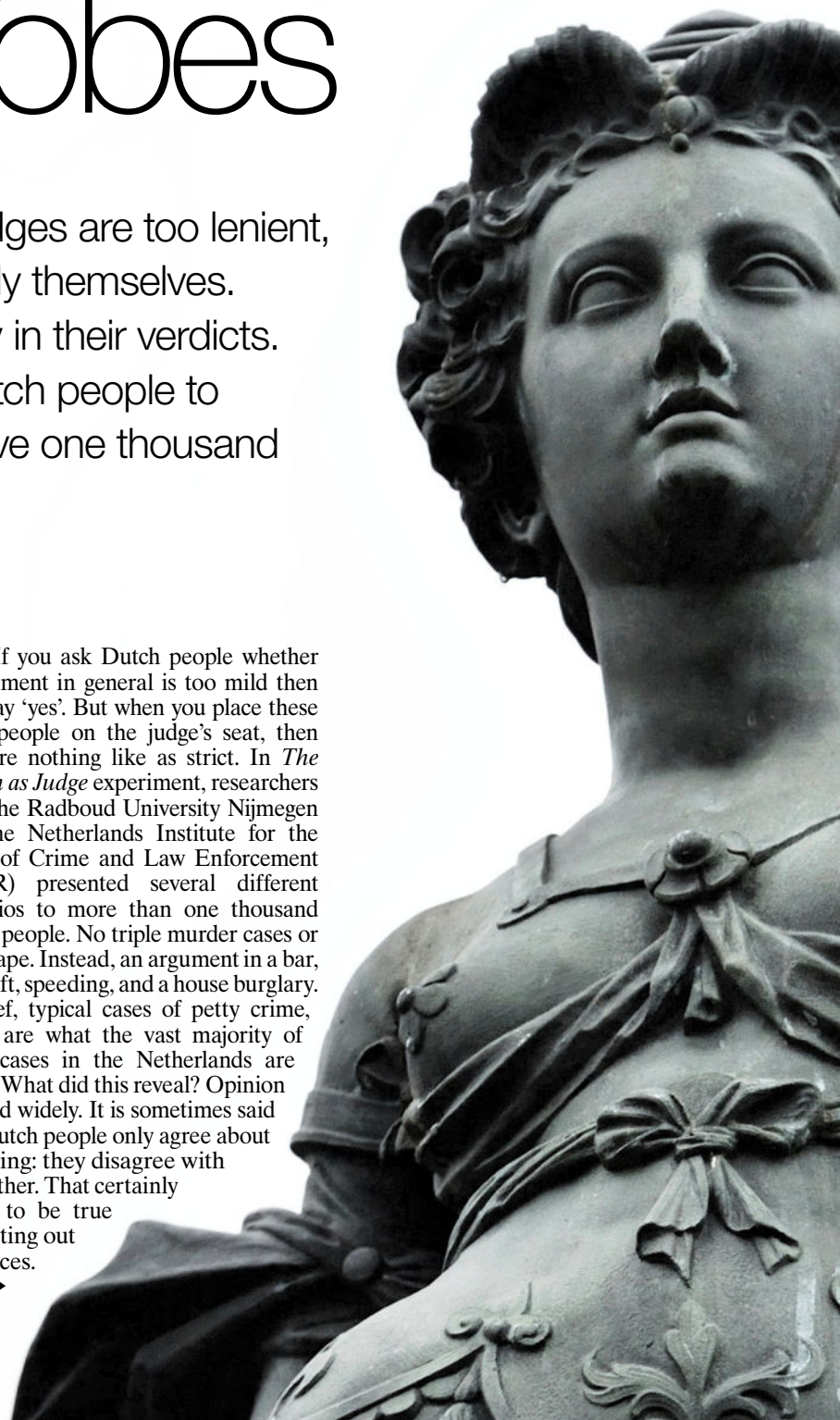
'At this moment I am investigating the role fat metabolism plays in ageing. I have received a Veni grant for this. In mice, we can indicate the biological age by performing measurements in the blood plasma. It should also be possible in people. It would be interesting to see if eating healthily, physical activity and, perhaps, nutritional supplements and medicines can turn back the biological clock. If I say that people often reply: 'Why would you want to do that? The world is already so full and then people will become even older still?' Yet that is not my main goal. My focus is remaining healthy for longer. That will lead to savings in health costs. I think people could eventually live healthily until the age of 120 years. With adjustments to their genes we can already make roundworms live for sixty percent longer.' ■

The Dutch say they are for harsh sentences but are strikingly lenient themselves

Everyone wearing robes

The Dutch often say that judges are too lenient, but they do not judge harshly themselves. However, they differ strongly in their verdicts. If you ask one thousand Dutch people to act as a judge you will receive one thousand different sentences.

TEXT: LEENDERT VAN DER VALK



An 18-year-old man must appear before the judge as he is suspected of sexually assaulting a 16-year-old girl. He groped the victim's buttocks without consent during an evening out. She reported this to the police. The perpetrator and victim belong to the same circle of friends. The man has never previously been convicted. If you were the judge in this case and you had to issue a prison sentence then for how many days would that be? Answer first, then read further.

The typical citizen does not exist

If you belong to the lenient quarter of the Dutch population then three days behind bars is more than enough. The strictest quarter want to lock up the man for at least three months. The average is 40 days. If a real judge issues a prison sentence for a mild form of sexual assault, then the average length behind bars is 41 days. If you ask Dutch people whether punishment in general is too mild then 75% say 'yes'. But when you place these same people on the judge's seat, then they are nothing like as strict. In *The Citizen as Judge* experiment, researchers from the Radboud University Nijmegen and the Netherlands Institute for the Study of Crime and Law Enforcement (NSCR) presented several different scenarios to more than one thousand Dutch people. No triple murder cases or child rape. Instead, an argument in a bar, car theft, speeding, and a house burglary. In brief, typical cases of petty crime, which are what the vast majority of court cases in the Netherlands are about. What did this reveal? Opinion differed widely. It is sometimes said that Dutch people only agree about one thing: they disagree with each other. That certainly seems to be true for meting out sentences. For ▶

Supporters of right wing parties (PVV and VVD) punish harsher

Sex and age scarcely seem to affect how citizens want to punish criminals. Political preference does though. People who support right-wing parties are more likely to advocate unconditional imprisonment than supporters of other parties. Fines are popular among supporters of the VVD and Christian parties. Groenlinks (Green Party) supporters prefer community service sentences, which are an abhorrence to PVV supporters. According to NSCR researcher Henk Elffers this means there is enough choice between political parties when it comes to criminal punishment. 'You can always find a party that thinks the same as you. It determines which party you support.' The Citizen as Judge study reveals that people have little confidence in society and favour a tough approach: more prison terms and higher sentences. These are mostly people who vote for the VVD and PVV.

Citizen judges frequently opt for community service

example, one quarter found that a shoplifter only needs to be imprisoned three days, whereas an equally large group thinks two months. This attracts considerable disagreement about each type of punishment. For each scenario, many people prefer prison. But also, many people prefer community services. Just as many people prefer fines. No two Dutch people seem to judge the same.

'The typical citizen does not exist,' concludes Professor of Criminology at the VU University Amsterdam and NSCR researcher Henk Elffers. As a rising number of people seem to be concerned about a growing gap between the citizen and the judiciary, Elffers and his fellow researchers conducted this experiment. 'The gap has been discussed for years. The fear is that citizens will no longer accept the verdict of judges.' Indeed, there is a group that wants far harsher punishments. 'However, that is not the majority. A significant group thinks roughly the same as a judge.'

Something else is happening. Citizens do not know all the facts. Elffers: 'The call for harsher punishment partly comes from ignorance. Most people base an opinion on cases presented in the media. They think of the Schiedam Park murder or the murder of Theo van Gogh and consider an 18-year prison sentence too light for such cases. In the Netherlands, there are only about 150 cases of murder and manslaughter each year. Many judges rarely or never see a murderer.' Elffers estimates that the many lighter scenarios presented to citizens in this study constitute about 95% of all court cases in the Netherlands.

Community service is popular

You might think the nation immediately wants to hang each criminal on the highest possible tree. Yet when the researchers asked Dutch citizens to act as judges they were found to judge more leniently than expected. For the ten scenarios presented, community service always received the most support. That is striking, since community service, or unpaid compulsory work, is under pressure in political circles for being too soft an option. Elffers: 'It did surprise me to a certain extent. Even in the case of violence and assault there is much support for community service. The Dutch were found to have a highly nuanced view of criminal law. Of course, they believe the criminal must be punished. Not only concerned about retribution, they also want criminals to be reformed.' According to Elffers, the political climate does not completely reflect public opinion. Over the past ten years, politicians have focused far more on harsh punishments. 'Crime has been falling for years, but the agitation about it is on the rise. Perhaps the group that wants harsher punishments is shouting hardest.' Whatever the case, it is not the voice of the majority, concludes the professor on the basis of this research.

If the citizens who acted as judges were told that community service also has more effect then they let even more criminals do community service. According to the researchers, convicted criminals are less likely to re-offend after community service than after a prison sentence.

Many Dutch people are not aware of that. If they are aware, then they sentence less harshly. There was also a group of citizens who received information about the high cost of a prison sentence, but this was not found to influence their judgement. So the cost of punishing criminals is less of an issue.

Citizens are lenient

How do the punishments from the average Dutch person compare to those of real judges? According to Elffers, it is hard to make a comparison. In the experiment, citizens were given a brief description of the offence and in the courtroom a judge sometimes has 'a dossier made up of 20 lever arch files'. Yet the researchers did try to compare citizens and judges. The conclusion: 'compatible leniency, different strictness'. The sentences of the mildest quarter of the population are about the same as mild verdicts from judges. The strictest quarter of the population judges more harshly than the judges who give the strictest verdicts. For example, during an argument in a cafe a victim incurs light injuries, a black eye. The mild quarter population thinks you should receive no more than five days in prison, whereas the mild quarter of legal verdicts state 14

You must feel punishment

For *The Citizen as Judge* study the respondents were presented with several statements about the purpose of punishment. Deterrence and retribution were the most broadly supported reasons. Citizens were less convinced about the usefulness of 'reaching an agreement'. A few statements with their score (1 means 'completely disagree' and 5 'completely agree'):

- 'dangerous criminals must be locked up for as long as possible in the interest of citizens' safety': 4.16
- 'punishment is getting what you deserve': 4.10
- 'punishment without a certain amount of suffering is not punishment': 3.89
- 'in criminal law there should be more opportunity for negotiation between the perpetrator and victim about resolving the conflict': 3.07
- 'it is more important that the perpetrator reimburses the victim for the damage caused than that he/she is punished': 2.95
- 'criminal proceedings are unnecessary if the perpetrator and victim have agreed upon a solution for the conflict': 2.61

Punishment scarcely prevents people from re-offending. In that respect a community service order works best.

days. Here citizens are even more lenient than the judges. The strictest quarter of the population want to lock up the suspect for six months. For the strictest quarter of judges, the verdict is 42 days. A difference behind bars of some five months.

Although the citizens positively surprise him, Elffers does not see the study as a call for trial by jury like in the United States. Juries there may not determine the severity of the punishment; only if the suspect is guilty. The (now deceased) legal psychologist Willem Wagenaar investigated 'lay jurisprudence' several years ago for the Dutch Judiciary and the Supreme Court of the Netherlands. Citizens were allowed to see the complete files plus all other information from the court the judges received. Their verdicts were not significantly different from those of the judges. Elffers: 'This call for harsher sentences is mainly based on newspaper articles. If they have to judge themselves, citizens become more similar to judges.'

Punishment has five purposes

Some people enjoy doing it. Punishment 'deliberately inflicts suffering', according to researchers. Why would you want to do that? Broadly speaking, we punish criminals for five reasons: retribution, as a deterrent to others, to remove dangerous nutcases from society, to resocialise criminals and to rectify the damage suffered. Those questioned could agree with these objectives. Does punishment really help to prevent people from committing crime again? 'Hardly,' says Elffers. 'To be honest punishment works very badly and stricter punishments work no better. We impose high traffic fines, but making them higher rarely leads to fewer offences. Of the punishments investigated, community service is the least bad. That sounds a bit despondent, which is also the case.' What does help,' says Elffers 'is better equipping people to live within the law.' Ensuring, therefore, that they have a chance in society. For example, allowing them to follow a better educational or training course. He underlines that the work of the rehabilitation service that organises courses in prisons is useful. 'But that is also just a drop in the ocean. Sometimes you can help people with a moral deficiency to see they are causing damage and suffering. Yet, alas, more often than not such efforts fail.'

Citizen shows understanding

Perhaps it is a good thing that the majority of citizens do not want to simply lock away everybody who breaks the law for eternity. Just like a judge, we take a lot of factors into account. Those with a criminal record, a re-offender, are given a heavier punishment than a first-time offender. Citizens give somebody who commits domestic violence an average punishment of 30 days in prison for a first-time offence. A re-offender can expect 90 days behind bars. If the victim is an ambulance worker then the perpetrator had better watch out. According to citizens a 'normal' fight that ends with a black eye is worth an average of 30 days in prison or a 500 euro fine. But if it is a paramedic who has been given a black eye then the average of 144 days behind bars or a fine of 1500 euros is imposed. The perpetrator's age is also taken into account. Juveniles are more likely to receive community service, whereas adults are more likely to receive a prison sentence or a fine.

There is another striking factor that the citizen as judge considers important: whether or not you have drunk alcohol. In the case of a traffic accident that counts against you. Drunken drivers are more likely to receive a prison sentence than sober drivers. If you hit somebody in a bar during a bout of drunken anger then respondents judge more leniently. The public clearly judges differently from the judge. Elffers: 'Intoxication is not included as a mitigating circumstance in the statute book. Rather the opposite is true.' ■

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Contrary questions

The NWO Spinoza Prize is the highest award in Dutch science. The winners receive 2.5 million euros that they can use for research of their choice. Annemarie Mol, Professor of Anthropology of the Body at the University of Amsterdam, is one of the four winners from 2012.

TEXT: ANTJE VELD

What did you want to be when you were younger?

'When I was at primary school, I wanted to be a writer. To be honest I have become one now, but instead of writing novels I write real-life stories. When I was 18 I started to study medicine because I wanted to understand what it is to be human. As I did not quite seem to learn that in my second year at university, I also started to study philosophy. And I did not become a doctor.'

What have you become then?

'An anthropologist of the West. I do research in everyday practices, in hospitals, care homes and laboratories. The knowledge that circulates there is part of my object. I investigate the language that people use to order reality. In the past, most anthropologists did their research in faraway places. They tried to make strange things familiar. I am among the anthropologists who turn things around and try to make the familiar strange. To do so, I use frictions within the Western tradition.'

Can you give an example?

'Take the example of tasting food. Everybody knows what it is, but I pose the question: 'What is tasting in practice?' A biologist might investigate cells in the tongue that are important to tasting. As an anthropologist, you explore how tasting happens at the dinner table. What do people say about it, how do they go about it, handle it? A colleague from India said: 'Tasting is very different when you eat with your fingers.' That made me wonder if it might be possible to say that the fingers taste. Since Aristotle, the senses have been classified such that the eyes see, the skin feels, the mouth tastes, et cetera. But what happens if you start to play with that? We tried it. We did an ethnographic experiment with a mixed group of finger eating experts and finger eating novices. The experts had cooked rice, lentils and vegetables and we all ate with our hands. Your fingers bring together some food, knead it a bit, make a little ball, pick it up and place it in your mouth. Try it! Of course it is possible to say: the fingers feel the food. But what if you say that they taste? What difference does that make? What do you learn from that? Asking such contrary questions is part of our research style. We take nothing for granted.'

What is the aim of your research?

'It allows for fresh forms of reflection. It helps to ensure that we do not continue to do things just because that is how they have developed. But that we instead ask ourselves each time: 'Is this wise? Can it be done differently?' In separate research projects we usually have specific aims as well. For example, I did research into eating in nursing homes. Dieticians assess food in terms of nutrients, chefs have to work with a budget, carers are mainly concerned about whether it tastes nice. I shadow each of them in turn and with my descriptions I try to reveal where the frictions emerge.'

Do you just describe?

I do not go to hospitals or nursing homes to work on improvement programmes. What I have to offer is something different. I shift questions. For example, I would not ask 'Is this good?', but 'What does appreciation involve?', 'How do people go about this in various practices?' And then I seek to draw lessons from that.'

And now you are a Spinoza laureate!

'Yes, I had never expected that because I do not discover any new facts, but work on new ways of thinking. I am the first anthropologist and the first philosopher to have won the prize. So I am particularly pleased about it. The Spinoza Prize is a recognition of my own work and the various disciplines I combine.'

What do you still want to become?

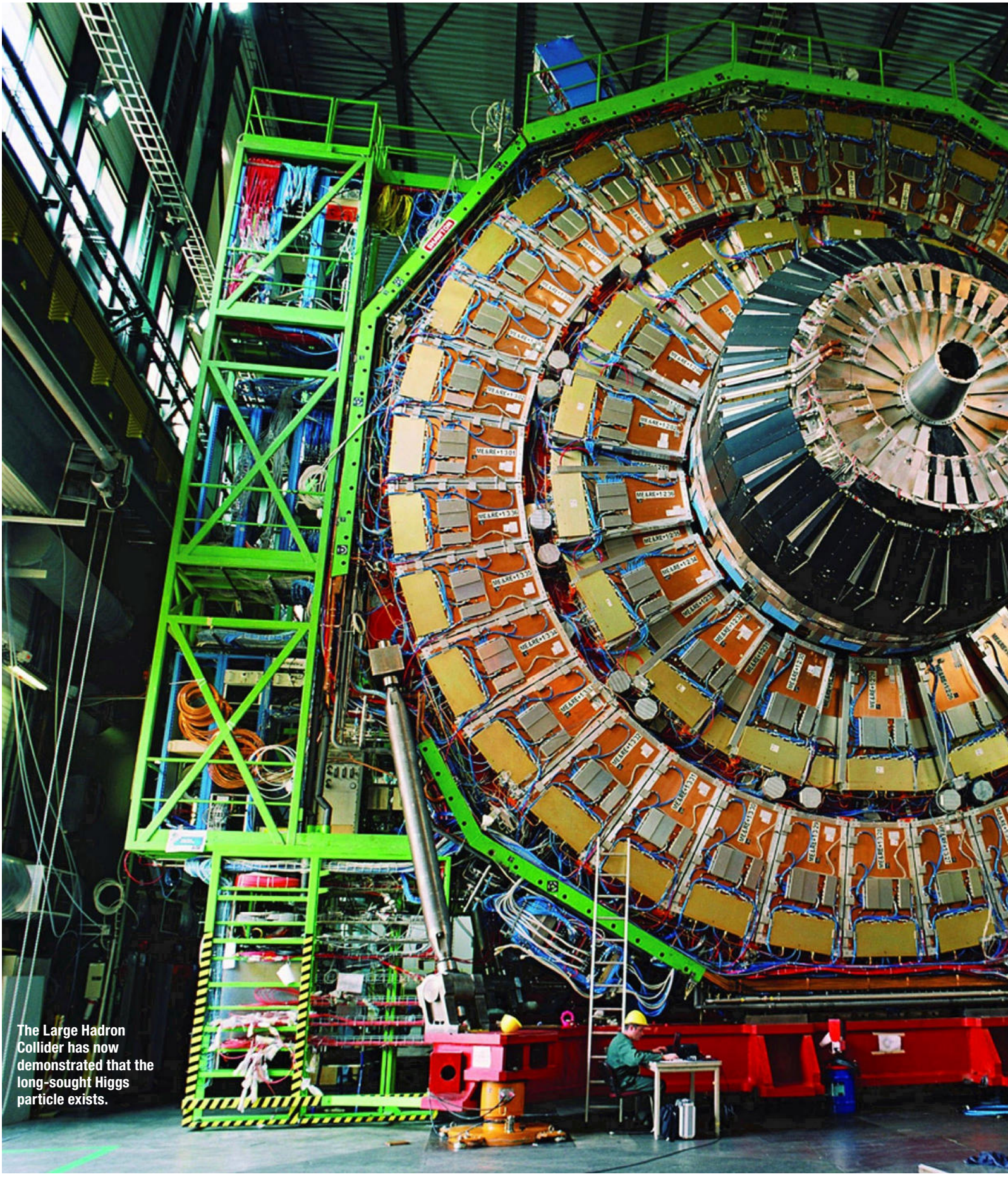
'I am currently working on a project about 'eating in practice and in theory'. I want to write a book about that. Then I would like to contribute to making anthropology and philosophy less caught up in Western concerns. Anthropologists who know a few cultures from the inside are interesting in that respect. For example, people who come from Korea, gained their PhD in England and did fieldwork in Ghana. By the end of my career, I would hope to still offer support to creative juniors.'

What are you going to use the prize for?

'For the research into 'eating in practice and theory'. In that project we are describing different practices associated with eating and trying to create a new language for this. That is ambitious, but so it should be for a Spinoza Prize.' ■

Biography Annemarie Mol

1958 Born in Schaesberg
1976 Grammar school education at Coriovallum College, Heerlen
1982 Degree in Medicine, free program, Utrecht University
1982 Degree in Philosophy Utrecht University
1989 PhD in Philosophy University of Groningen
1997 Socrates professor Political Philosophy at University of Twente
2008 Socrates professor at University of Amsterdam
2010 Professor of Anthropology of the Human Body, University of Amsterdam



The Large Hadron Collider has now demonstrated that the long-sought Higgs particle exists.

From lab to market

Scientists make discovery after discovery. But how do you go from scientific discovery to practical application? And could that process be accelerated?

TEXT: JERWIN DE GRAAF

Almost every month there is a news item about the latest breakthrough in the field of batteries. Yet in 2012, we still needed to connect our smartphones to a battery charger each day. Why is it taking so long before we see a practical application from all those breakthroughs? Wim van Saarloos (57) director of the Foundation for Fundamental Research on Matter (FOM), part of NWO, responds with a counter question: 'Does it really take so long before we can pluck the fruits of science? I can remember that there were no cordless drills when I was about 25 years old.' Hardly surprising, because such a drill needs strong magnets and good batteries and neither of these were available. Van Saarloos: 'Now that we have those magnets and batteries, we also have cordless drills. We have these thanks to scientific research. Yet nobody still marvels at that because a cordless drill has become so normal.' The same applies to laptops and smartphones. They have only become available recently due to a series of breakthroughs such as thin LCD screens.

Aims differ

Of course not all scientific discoveries immediately lead to a drill, laptop or smartphone. Yet in many cases that is not even the aim. 'You can do scientific research with two thoughts,' says Van Saarloos. On the one hand out of curiosity. A good example of this is CERN. That is the European organisation for nuclear research, famous for the enormous particle accelerator at the border between Switzerland and France: the LHC (Large Hadron Collider). The LHC is the largest scientific undertaking ever. This enormous piece of equipment underground cost more than 6 billion euros and was only built to allow the building blocks that everything is made of (elementary particles) to collide with each other with considerable energy. CERN is not usually directly interested in the practical applications of its research. Their aim is to understand the building blocks of the universe and also to investigate whether the theories about these are true. Nevertheless, the research has yielded many innovations. For example, the world wide web (the manner in which Internet pages are linked to each other) was devised at CERN. And PET scanners, which doctors use to detect tumours, were also partly made possible by CERN. 'The scientific research can also be ▶

The result of Pasteur's practical is fundamental knowledge

aimed at a practical application or the solving of problems,' says Van Saarloos. The people who do this 'application-driven research' have a practical application in mind. Their research must yield a new or an improved product or idea, such as a more efficient solar cell, a stronger laser or a new type of cancer treatment. In other words: more than just knowledge.

Sun makes fuel

Satisfying our curiosity is all very well, but a construction such as the LHC is far from cheap. Why would you invest 6 billion euros in a project that does not yield a single practical application? 'Because both types of research are needed,' answers Van Saarloos. 'For example, you often need fundamental knowledge before you can make a practical application.' An example: scientists are working on solar cells that produce a hydrocarbon fuel (such as petrol). Because in theory that is possible. Only we still need to determine exactly how to do that. Research that somebody does out of pure curiosity can lead to applications that are unexpected, like CERN. Application-oriented research can open up the way to new fundamental research. The French chemist Louis Pasteur (1822-1895) wanted, for example, to reduce the number of harmful bacteria in food to a safe level. He succeeded in that by briefly heating the food. Thanks to Pasteur's application-oriented research we can now drink milk without becoming ill. He also ensured we better understand the world of microorganisms. 'Because of this he became one of the founding fathers of microbiology,' says Van Saarloos. 'Since it was a new discipline, fundamental research had to be done. Pasteur indirectly made fundamental research possible. In brief: it does not have to be one or the other. The two can work well together.'

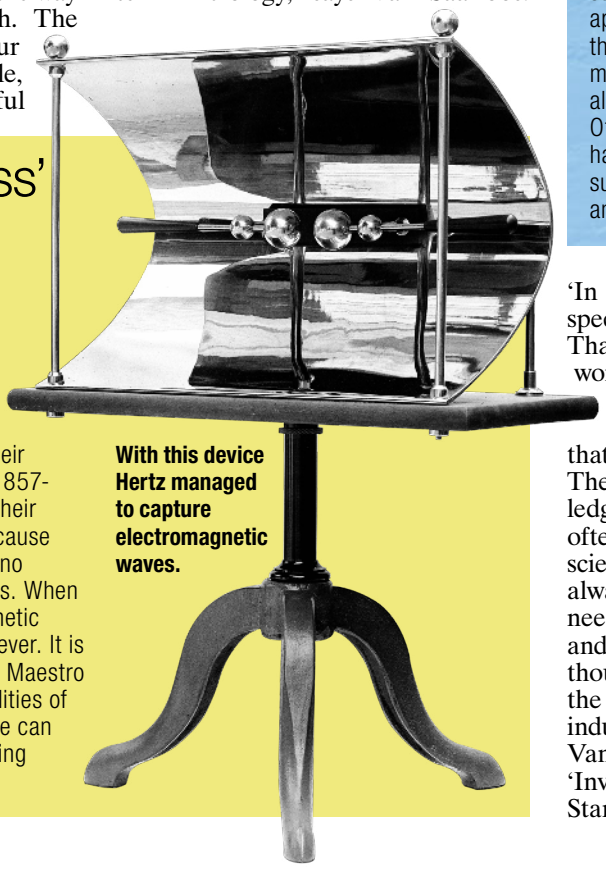
Cycle is ecosystem

How do you progress from a scientific discovery to something useful? The route from laboratory to practice is sometimes compared to a pipeline. At one end you pour in fundamental research and at the other end practical applications emerge after a while. Yet according to Van Saarloos that is not how the knowledge cycle works. It is not a one-way traffic system, but an interaction: not just between researchers, but also between researchers and industry. 'Compare it with an ecosystem in biology,' says Van Saarloos. 'In an ecosystem, plant and animal species are dependent on each other.' That is also how the knowledge cycle works. Only in this case it does not concern plants and animals, but scientists, investors and industry that are dependent on each other.

The problem with the Dutch 'knowledge ecosystem' is that companies often do not have a clue about what scientists are doing. Scientists do not always know what companies want or need. The separation between science and 'industry' is relatively strong, even though the situation is improving. In the United States, universities and industry are far more interconnected, Van Saarloos knows from experience. 'Investors sit in the lecture theatres of Stanford University in Silicon Valley to

'Radio waves are useless'

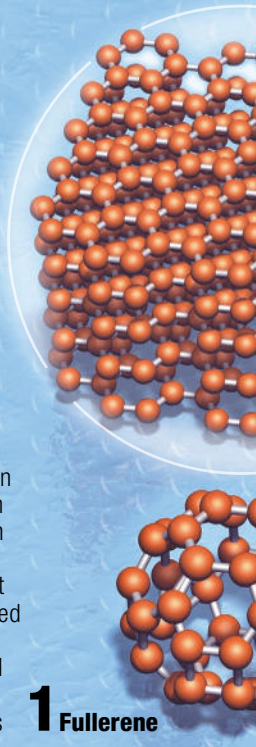
Scientists who do research without having a practical goal in mind, sometimes accidentally stumble across something that makes new inventions possible. They do not always realise that themselves. An old, but a well-known example, is the discovery of electromagnetic radiation. In the 19th century, the British mathematician James Clerk Maxwell had predicted the existence of electromagnetic waves. Yet nobody had proved their existence. The German physicist Heinrich Hertz (1857-1894) devised an experiment that demonstrated their existence. We can be thankful to him for that, because without electromagnetic radiation we would have no radios, televisions, microwaves and mobile phones. When Hertz's students asked him what use electromagnetic waves had, he replied: 'They have no use whatsoever. It is nothing more than an experiment that proves that Maestro Maxwell is correct.' Other people saw the possibilities of electromagnetic radiation, fortunately, and now we can warm up a meal while we sit on the couch switching between TV channels.



With this device Hertz managed to capture electromagnetic waves.

Graphene is highly promising

For most scientific discoveries, it takes a while for practical applications to emerge. Sometimes we discover something that the scientific world dives in on. Then things can go really fast. In 2004, the Dutch-Russian physicist Andre Geim and former FOM PhD student Konstantin Novoselov discovered graphene. Graphene has the shape of chicken wire, and is just one carbon atom thick. It has many useful properties. With a simple piece of tape, Geim and Novoselov managed to remove some of the wonder material from the tip of a pencil. In 2010, they received the Nobel Prize in Physics for their graphene research. In that same year, more than 3000 scientific articles on graphene were published, and more than 400 patent applications were submitted with graphene as the subject. The first practical applications are now on the horizon. Touchscreens made with graphene are almost on the market. Other types of carbon also have a promising future, such as carbon nanotubes and fullerene.

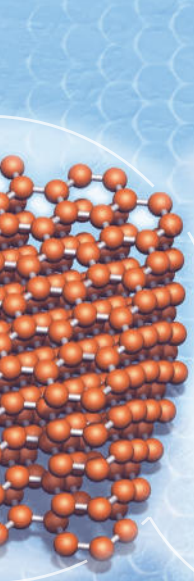


1 Fullerene

Flexible
Researchers from the University of Sydney in Australia have developed graphene sheets that are as flexible as paper and stronger than steel.

Conducting
Graphene conducts so well that experts view it as the new silicon. Computer chips made from graphene will soon become available.

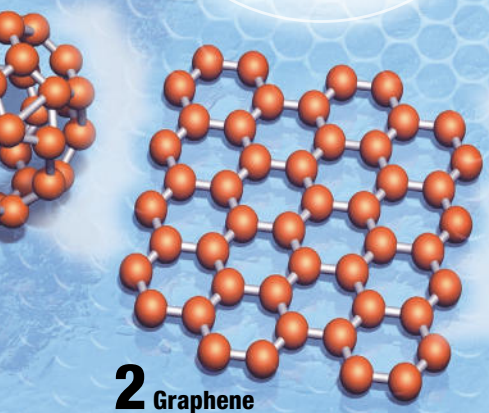
Sensitive
Researchers from Stanford University have produced an elastic 'skin' from carbon nanotubes that is pressure sensitive.



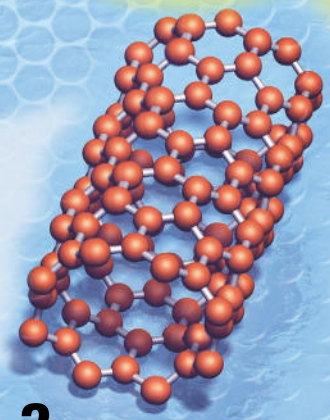
Carbon
Carbon has far more exotic forms than graphite (top and left). The ball shaped molecule (1) is called fullerene. A single layer of carbon atoms is called graphene (2). And elongated cylindrical structures are called carbon nanotubes (3).

Applications
Although graphene and nanotubes are recent discoveries, it will not be long before the first applications reach the market.

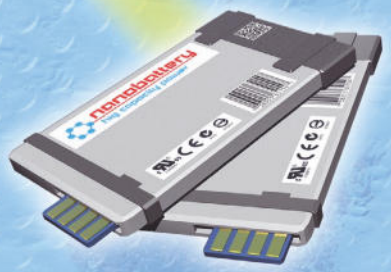
Light
A new material containing carbon nanotubes can absorb 99.5% of the light it captures. Useful for sensors in telescopes.



2 Graphene



3 Carbon nanotubes



Energy
Batteries with an electrode made from graphene can store energy faster and better. This material will also be found in the battery of the future.

ask the professor questions. Simply to find out if they can do something with his knowledge.' In addition, companies often employ top scientists as a consultant who visits the company once a month. Companies and universities are more aware of what is going on in the field. The most important difference is that it is far easier for students and scientists in the United States to start their own company. In Silicon Valley, the technology centre of the world, where hundreds of small, innovative companies are huddled together. Many of those companies have been set up by students and scientists from Stanford University. The founders of Google, for example, did PhD research there while constructing their world-famous search engine.

Change the culture

If the contact between industry and science is good, then the pathway from lab to practice is automatically shorter. So Van Saarloos thinks it must be made easier for Dutch scientists to start a company. The problem is that scientists in the Netherlands are employed by the semi-private sector. That makes it harder for them to establish a start-up in their 'employer's time' when they will benefit financially from this. Some private universities in the United States accept that a professor can be involved in a start-up company one day per week. Any financial benefit he receives is not a bad thing because ultimately the entire system benefits. 'I personally believe that there should be more space in the Netherlands for that,' says Van Saarloos. 'That will, however, require a change of culture.'

In 2011, the Dutch Cabinet launched a plan to accelerate innovation. It has designated nine top sectors, such as water, chemistry and energy, where the Netherlands has an outstanding international reputation. There should be more colaboration between universities, government and industry. Companies should invest in research. The FOM Foundation is already a contributor. 'A researcher from AMOLF, one of our research institutes, has already been working at Phillips for five years doing research into nanophotonics,' says Van Saarloos. In other words: the use of light on a very small scale. In the future, nanophotonics might make possible new applications in areas like communication technology, lasers and solar cells. Van ▶

Will the Netherlands become the Silicon Valley of Europe?

Saarloos: 'Now Philips is starting to see that there is a wide range of unprecedented possibilities, and it wants to expand the collaboration.' So sometimes it takes a while before scientists and companies realise how they can help each other. Once things have got that far, everybody benefits from it. Then innovation can suddenly speed up.

Silicon Valley.nl

NWO brings together scientists and companies in different ways. Technology Foundation STW, for example, mainly funds fundamental research. 'And yet researchers who submit a plan must also indicate who will be the possible users of their research results,' says Van Saarloos. 'Those users must also contribute to the research. For example, by co-funding or by making facilities available for it.' The FOM Foundation also has an 'Industrial Partnership Programme' aimed at facilitating this type of partnership. Thanks to all these efforts, it is easier for scientists and companies in the Netherlands to find each other.

Scientists are increasingly required to think about how they can make use of their knowledge. This is referred to as valorisation or knowledge utilisation. Van Saarloos would like the Netherlands to become a 'Research and Innovation Delta' just like Silicon Valley. According to him, we are not far off achieving that goal. Performing well in science, the Netherlands has a good name in the natural sciences. We are leaders in physics, chemistry and materials science. We are such a small country, so all that knowledge is close together. Van Saarloos: 'I always put it like this: the Netherlands is not much bigger than Silicon Valley.' ■

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Louis Pasteur laid the foundation for microbiology in this lab.

! FURTHER INFORMATION

www.fom.nl: website of the Foundation for Fundamental Research on Matter (FOM).
www.stw.nl: website of Technology Foundation STW.

A PET scanner is a good example of a practical application that emerged from fundamental research.

SARAH DURSTON (38),
Professor of Developmental Disorders of the Brain at the Department of Psychiatry, University Medical Center Utrecht, received a Vici in 2011.

Veni, Vidi, Vici

Talented scientists with an innovative research plan can obtain funding from NWO. For researchers who have recently gained their PhD, there is the Veni grant worth a maximum of 250,000 euros. For more experienced scientists, there is the Vidi grant worth 800,000 euros. The Vici, worth 1.5 million euros, is for senior scientists.

You received a Veni, a Vidi and then a Vici. That rarely happens. How did you do that?

'I will have to speculate, as I did not see the competing proposals. It probably worked in my favour that research of ADHD is societally relevant and that people have a concept of what I study. It was probably also important that the research is internationally supported and is innovative. It probably also helped that with three proposals in eight years a continuous line of research developed.'

What are you using the money for?

'My research focuses on understanding the biology of ADHD so that we can come up with better treatments. For example, I study brain development in children with ADHD. We mainly do that using MRI scans. What changes as the children become older? 'With the Vici grant, I could expand my research group with two research assistants, two PhD students and a postdoc. We continue to focus on 'imaging' ADHD: making pictures of the brain with MRI. Children can sometimes find it intimidating to go into an MRI scanner. It can be intimidating, even for adults. So I asked a cabinetmaker to construct an MRI simulator. Participants can now practice in this before they participate in the study. These simulators are now found in hospitals across the country.'

How did you end up in this line of work?

'During my degree in biopsychology I did an internship with the group here studying schizophrenia. Even then, I was primarily interested in the brain, how you can image it using MRI scans and how you can measure and assess it. I can still remember the beautiful neuroimaging pictures in a book about biopsychology. I knew already that I wanted to study people and I was primarily interested in the development of children. All of these aspects have come together in my research.'

What would you still like to investigate?

'I enjoy our research because it combines so many different approaches. It combines genetics, biology, cognition and psychiatry. The results are always correlational by definition. You can find a relationship between event X and event Y, but is that because X leads to Y or is there a Z that causes both? With this type of research we often simply do not know. One way of tackling this problem is to work with animal researchers. It is easier to manipulate laboratory animals than people. It is. for example, easier to investigate the effects of genetic differences. Such collaborations, however, are still relatively rare because animal researchers and human researchers often do not speak the same language. I would like to expand our efforts into that area.' ■