issue #2

UNIVERSITY OF TWENTE.

Cybercime: the new Cold Var

Science & Technology Magazine

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Let us know what you think!

he inaugural edition of this magazine was published back in May. For this second edition, we have changed the magazine's name slightly. We feel that **U-Today Science & Technology Magazine** is a better title for this publication. What did not change, however, are the contents: interesting background stories about research conducted at the UT, inspirational interviews with scientists and young research talent and an in-depth cover story.

Based on the many positive reactions our editors received after the publication of the first edition of our magazine, you very much enjoyed what we have to offer. A particularly wonderful compliment came from UT professor Frank van de Velde, who said he was 'very impressed.' He called the first edition a 'beautiful magazine that places the UT in a good light.'

Such comments strengthened our conviction to continue on our chosen path. To once again produce a 'beautiful' magazine, our journalists travelled all over the country for the stories in this edition: they visited the Ministry of Security and Justice in The Hague and the Wetsus research institute in Leeuwarden. Some extensive photo shoots took place 'way up north' in order to capture the membranes as well as possible. The results can be seen on page 20.

We also devoted a lot of time and attention to our cover story: Cybercrime. We interviewed four UT scientists who use their expertise to shed light on a world of shadows that remains hidden from most of us. Mostly, they discuss how we can make our society more secure and what interesting scientific challenges that entails.

In short, this edition of *U-Today Science & Technology Magazine* is definitely worth reading. Be sure to let us know what you think of it. We would also love to hear from you about which interesting research projects or themes you would like us to cover in our next edition, which is scheduled for publication this winter.

Maraike Platroet

Editor-in-chief at U-Today





Colophon

This University of Twente Science & Technology Magazine is made by U-Today (previously named UT Nieuws), an independent journalistic medium at the University of Twente (UT). This magazine with a unique focus on UT's research and scientists is currently published three times a year.

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U-TODAY

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Text: Rense Kuipers & Rik Visschedijk Photos: Gijs van Ouwerkerk & Shutterstock

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'IT IS SOMETHING OF A MIRACLE THAT THERE HAS NOT BEEN A MAJOR ATTACK YET'

Cybercrime: The new Cold War

What if... airports are shut down, public transport is in disarray, and supermarkets are unable to restock their shelves because their systems have been taken offline? It would result in complete social chaos. Welcome to a world you cannot see: the world of cybercrime and the people who defend us against it. Before it really is too late.

errorists could potentially cause a lot more damage and harm than they are currently doing with their attacks all over Europe,' says Aiko Pras, professor of Network Operations and Management. 'If you digitally knock out Schiphol Airport, it would create total chaos. Airplanes can no longer take off and passengers would not receive any information. That would be the perfect time for terrorists to attack, because all your victims are already herded together and in a state of confusion.'

He had some doubts about whether or not to share this example. However, the professor in the Design and Analysis of Communications Systems (DACS) department knows that criminal minds can also come up with scenarios such as this one without his help. 'The problem with this kind of scenario is that it is hypothetical. I cannot concretise how enormous the consequences of a major digital attack combined with a physical strike will be. I can only warn of the dangers, because the technology needed for a large-scale cyberattack is not all that complicated. Just look at teenagers who knock down their school's internet just to get out of a test.'

Crime for everyone

The digital age marks a new era for our society. Everything and everyone is connected to the internet and even critical infrastructure comes with internet protocols. Pras believes this raises new questions about our security – on a global scale, even. After all, when you give everyone access to the internet, anyone with sufficient knowledge can take advantage of it. 'An important characteristic of the sovereign state was the monopoly on violence,' he says. 'The state was in control of the weapons, from assault rifles to tanks and nuclear devices. Because of the internet, everyone now has access to the means to commit acts of digital violence.'

As a result of this 'democratisation' of violence, we are engaged in a new Cold War, Pras believes. There are some significant differences, however. 'All countries have programmes that they keep strictly confidential. They do not want to reveal how advanced they are and what they are really capable of. During the Cold War, it was all about showing your strength and deterring the enemy. Another difference is that cyberweapons are ridiculously cheap. The smallest nations can



Famous hackers

Who have left their marks on the digital world forever? Here are five of the world's most famous hackers:

- Kevin Mitnick. Committed his first major hack at the age of sixteen. Some time later, he cracked the systems of the Pentagon, the NSA and major organisations such as Dell and Compaq.
 He was arrested and spent five years in prison, including eight months in solitary confinement because people believed he could start a nuclear war by whistling into a telephone. Mitnick was released in 2003 and currently works as an internet security consultant.
- Adrian Lamo. Hacked into the systems of Yahoo, Microsoft and the New York Times. Was given a two-year suspended prison sentence. He joined the other side in 2010, when he reported Bradley Manning to the American authorities for leaking hundreds of thousands of confidential documents to WikiLeaks.
- **Gary McKinnon.** Responsible for 'the largest military hack in history.' In 1997, he infiltrated the computers of the American army and NASA. He claims his goal was to find information about UFOs. He posted a message that read 'your security is crap' on the websites he hacked. The British ultimately did not extradite him to the United States.
- Albert Gonzalez. Stole more than 130 million credit card details between 2005 and 2007. He is currently serving a twenty-year prison sentence.
- Anonymous. Not a single person, but an anonymous, decentralised and virtual collective of so-called 'hacktivists'. As 'digital Robin Hoods', this group has already attacked Amazon, PayPal, Sony, the Westboro Baptist Church, the Church of Scientology and several governments.



develop the most serious weapons and even the nation states are acquiring digital weaponry.'

From basement hacker to terrorist

Researcher Roland van Rijswijk, a member of Pras' department, confirms his thesis supervisor's words. He combines academic knowledge with practical experience in his role as Research & Development project manager at SURFnet, which manages Dutch educational and research networks – including that of the UT. 'Cyberattacks are becoming more serious and complex in nature,' he says. 'Around the turn of the century, the first Distributed Denial-of-Service or DDoS attacks were committed. Over the past five years, the strength of these attacks has become a serious problem.'

In his line of work, securing universities, such

'The internet is like an adolescent with growing pains'

DDoS attacks are an everyday occurrence. 'A few years ago, so-called booters began to appear. These are online services where you can buy an attack. The term 'booting' comes from the world of videogaming and refers to kicking someone out of the game. That is exactly what happens to a network during a DDoS attack. A server is overloaded with 'visitors,' it cannot deal with the volume of traffic and goes offline. Students try to knock down their educational institute, for example to get out of an exam,' says Van Rijswijk. He is quick to add: 'Before you get any ideas, remember that you risk a four-year prison sentence if you do something like this.'

The researcher, who recently earned his PhD cum laude in Pras' department, differentiates between various levels of cybercrime. First of all, there are the large-scale attacks that involve breaking in and stealing, eavesdropping and sabotage. 'That is the domain of terrorists, nation states and large-scale industrial espionage,' he explains. 'Examples include Americans tapping the phone lines of the German Chancellor Merkel, terrorists who just want to destroy something or companies out to steal the latest technological developments from their competitors.' Other forms of cyberattacks include phishing, ransomware and blowing services off the internet. That is usually the work of 'basement hackers.' However, in the playing field that exists between these loners on the one hand and nation states on the other, highly organised groups operate. 'This type of cybercrime has been given



an entirely new dimension following the recent cases of CEO fraud. The attackers carefully prepare their scam. They might, for example, create an account and ask a secretary to quickly transfer a large sum using phrases that the CEO would use. The receiving account is of course owned by the attacker.'

This is in line with the image that professor Marianne Junger, professor of Cybersecurity and Business Continuity, has of hackers: 'Only around twelve percent of the hacks appear to originate outside of the Netherlands,' she says. 'That is not all that surprising. If you want to hack a specific target, like a CEO, you have to master the language and be nuanced. Attacks on a larger scale, such as the recent ransomware attacks, usually do come from abroad.'

High-risk game

According to Van Rijswijk, the criminals invest significantly into this kind of 'local' attack, which

can often take months to prepare. 'The scammers take their time getting to know the CEO and the business,' he says. 'Next, they register thousands of domain names and link email addresses to them. That requires an investment of tens of thousands of euros. You might compare it to gambling in a casino. The higher the bet, the higher the potential profit. It is a high-risk game, but the pay-off of a successful scam is enormous.'

It is clear that this type of phishing is not done by a lone hacker in a basement. 'This is a form of organised crime,' says Van Rijswijk. 'That is what makes it so dangerous to go after the criminals.'

Even parties we would normally consider to be the good guys hack computers. 'The most dangerous methods are adding software or deliberately including faults in the system,' says Pras. 'These contain so-called backdoors through which one can later break in. Secret services –

Hack the hacker

What to do with hackers? 'The best solution is to hack them back,' professor Aiko Pras believes. 'The only question is what you will find on the other side. That is why we only focused on teenagers in basements for a long time. I am becoming increasingly interested in the big players, though, and that road quickly leads to e.g. the Russian mafia. That is a dilemma I struggle with. The same goes for the collaboration within our group with students from countries such as China or Iran. We work with confidential databases and research potentially sensitive networks. I do not want to put these students, who of course have ties to their native countries, in a dangerous situation, because their governments will stop at nothing.'

> meaning governments – frequently use this tactic. It is not just the rogue states, either; western nations use this method too. The government of Bavaria admitted to using this tactic in 2011 and the Snowden publications have all but confirmed that the US also uses backdoors. That is a major problem, because if these backdoors are found, anyone can access them.'

Cybersecurity and privacy

Politicians, policy makers and scientists are all familiar with the problem of cyberattacks, phishing and fraud. 'Policies designed to protect us immediately lead to a different problem,' says Andreas Peter, researcher in the Services, Cybersecurity and Safety department. 'Namely: privacy. Of course, it is important to fight against crime, but not at the expense of everything else. As a tax payer in a democracy, you have certain rights and liberties – even digitally.'

'Online, women make up a larger share of the criminals' It would seem like a simple trade-off: if a government wants to adopt stricter security measures, that will always compromise people's privacy. 'After all, the goal is to break through digital anonymity,' says Peter. 'That is only possible when you know who is online and what they do on the internet. Since the introduction of the Patriot Act, following the terrorist attacks in 2001, the American government has more authority to monitor people. Nation states take things one step further when it comes to watching their own citizens. They spy on people in secret and draw up far-reaching legislation to make this practice legitimate.'

Privacy does not necessarily come at the expense of security and vice versa, Peter says. He uses the distribution of and fight against child pornography as an example. 'We know that distributors tend to use corporate networks to hide their identity,' says Peter. 'The police have a large database of information that they would like to link to corporate systems in order to filter out illegal content and its senders. However, it is a gigantic leap from a privacy perspective to give police access to all communication that takes place within an organisation.' His group was therefore commissioned by the police to develop a system for 'revocable privacy.' 'Your personal information will remain private, unless there is a good reason to suspend that privacy.' The system works by using cryptography. 'We install a kind of black box in the corporate network, in which the police database is cryptographically hidden in such a way that criminals cannot access it. In the end, we only see results if there are similarities between the police's data set and what the system finds on the corporate network. We can only revoke someone's privacy if the system detects any pornographic content. This method allows us to build privacy ethics into the system itself.'

Digital licence plate

The line between security and privacy is not as clear to Marianna Junger as her colleague Peter suggests. 'When I drive onto the highway in my car, I can be recognised by my car's licence plate. That is no different from the way your IP address makes you digitally recognisable.' To her, the internet is an open system that was developed in good faith. 'The downside of that open and anonymous nature is that hatred, crime and bullying are abundant on the internet. We have yet to find the right balance between openness and security.' With her group, Junger researches internet abuse and how people behave in cyberspace. 'This is a difficult field,' she says. 'There is hardly any information to work with. Normally, you would base your research on extensive studies of victims, but these are hardly available in the world of cybersecurity. Victims such as major corporations or banks are not interested in publicly announcing that they were attacked. This complicates our research into large-scale fraud.'

The human factor is a key aspect of Junger's research. 'Of course, technology is important in the world of cybersecurity,' she admits. 'However, we are seeing more and more that human actions are the decisive factor. Victims easily give up their own personal details when they receive a call or an email, they lose their phone that contains sensitive information or they use weak passwords. People are still the weakest link in the cybersecurity chain.'

Because of ongoing digitisation, the profile of the criminal has also changed. 'People are more tempted to engage in illegal activities online. Whether it concerns slander or fraud, the digital line is easier to cross than the one out in the 'real world," Junger explains. 'Online, women make up a larger share of the criminals than they do in real life. In general, however, you might say that every bad character trait someone





has also exists online, sometimes in an exacerbated form. The anonymity of the internet brings out the worst in some people.'

'The Internet of Shit'

The internet is a platform to which we are all connected, which is not all that difficult to hack and for which the rules are still poorly defined. It is like an adolescent with growing pains. We are forcing this adolescent to grow ever larger and ever faster. Due to the rise of the Internet of Things, we are connecting more and more devices to the internet. It is no longer just our computers and smartphones that are connected to the web; so are our printers, surveillance cameras, thermostats, et cetera. Our vacuum cleaners, refrigerators and kettles are not far behind. Roland van Rijswijk says what is one everyone's mind: 'Do we really need all that?'

He calls it 'the Internet of Shit.' 'We are heading towards disaster because we surround ourselves with cheap junk from Asia. Do you really believe that products sold at such low prices were developed with any concern for cybersecurity? I would never install any of those cheap security cameras in my home or use a baby monitor with a Wi-Fi connection. You never know who else might be watching.'

Pras wholeheartedly agrees. 'When a Chinese range of surveillance cameras is hacked, who is responsible? The manufacturer in China, the supplier or perhaps the consumers themselves, because they should have known the product was crap. There is no answer yet to this question of liability, but the discussion is sure to arise at some point.'

Another element is – once again – the difficult question of privacy. 'These devices often also communicate with their manufacturer,' Van Rijswijk illustrates. 'That means databases are filled with information about my behaviour. When I control my thermostat with an app, my energy company knows I am home. The same goes for the manufacturers of my vacuum cleaner, my surveillance cameras and many other devices. Do you really want to share all that information with everyone?'

Marianne Junger already suggested that people are the weakest link when it comes to cybersecurity. The same goes for online privacy. 'Apparently, we want free services and do not care very much about our privacy,' she says. 'For now, I will consider that a given.' Andreas Peter shares her view: 'We are clearly very satisfied with services such as Google and Facebook and we hardly care that they track everything we do and claim our data, only to sell it to advertisers.'

> 'The anonymity of the internet brings out the worst in some people'

Peter does have a problem with the unrestricted collection of personal information by a few major organisations. 'We have to take back control of our own data and stop relinquishing our privacy quite so easily. Encryption should be the standard for all data traffic, not just an option.' A relatively small group of internet users is already doing so by using more privacy-aware alternatives such as DuckDuckGo instead of Google, Diaspora instead of Facebook and SpiderOak instead of

COVERSTORY

Dropbox. 'There are also alternatives for Gmail, like Proton-Mail. Yes, you have to pay a small annual fee, but that does make it a lot harder for Google, and therefore the American intelligence agencies, to spy on you.'

The big game

Each of the researchers indicates that we have significant personal responsibility when it comes to cybersecurity. However, what about the 'big game,' the nation states that spy, eavesdrop and steal? 'That topic is slowly receiving more attention,' says Pras. Several years ago, cybersecurity was added to the agenda of the Munich Security Conference, where he was a speaker. 'One hundred million was allocated to diaital security. It is a drop in a bucket, but it is also a good start.' 'The problem with cybersecurity is that the problem is largely invisible,' says Pras. 'Literally and figuratively. Politicians are unaware of the risks and advisers and policy makers know everything about yesterday's threats but little to nothing about the dangers of tomorrow.' This means the researchers' job is two-fold: making sure that the systems are optimally organised and informing the public and especially governments about the dangers of cybercrime. 'In the meantime, the best we can do is put out one little fire at a time,' Van Rijswijk agrees.

Hackers, terrorists, countries arming themselves in secret... How can we possibly defend ourselves against cyberwarfare? 'First of all, we must realise just how vulnerable we are,' Pras continues. 'Once we come to terms with that, we must realise that we need a contingency plan. How can we communicate in the event of a large-scale attack and who is responsible for what? Last, but certainly not least, we must make the internet divisible. If one part is under attack, we can quarantine it and keep other parts secure.'

Pras emphasises that these measures are desperately needed, because the dangers are enormous. 'The internet is currently in the hands of a bunch of cowboys. Even at the state level, everyone is just messing around without marking ethical boundaries. Take the French secret service, for example. Their job description openly states that they engage in corporate espionage. The EU and the United Kingdom spy on each other to achieve the best possible negotiation position regarding Brexit. Then there is North Korea: that country is not connected to the internet and is therefore out of our reach, but it could still hold the rest of the world hostage. Believe me, it is something of a miracle that there has not been a major attack yet. It is only a matter of time.' •



Experts who contributed to the article:

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POP Culture

We binge-watch one Netflix series after another, we devour movies and games. Often it is no more than mindless entertainment, while at other times it even raises scientific questions. Pop culture, viewed through the eyes of a scientist.

n this second edition, the TV show Mr. Robot (2015 present) is analysed by Luuk Hendriks, PhD candidate at Design and Analysis of Communication Systems (DACS). For those who have not seen this show yet, beware of spoilers!

The plot

During the day, Elliot Anderson (played by Rami Malek) works for an internet security company, while he leads a double life as a hacker at night. The anarchistic 'Mr. Robot' recruits him into the 'fsociety' hackers' collective, whose goal is to destroy the debt records of E Corp. In this fictional universe, E Corp is the world's largest conglomerate. With their hack, the group wants to achieve the collapse of the global financial markets.

First impression

Hendriks: 'It has been a while, but I enjoyed watching Mr. Robot. The remarkable thing is that I encountered hardly any errors in the storyline. That is quite unusual. When you turn on the news, hacking is usually misrepresented entirely. When the presenter opens an htop screen on their computer, that might look interesting to a layman, but it has nothing to do with hacking.'

'It is not just the technical aspects of this show that are believable. Mr. Robot has a dark and dystopian edge with characters who are – as we say nowadays – on the autistic spectrum. Although that is a generalisation, it is appropriate for a subculture that mostly consists of young loners.'

Realism/feasibility

'The premise of the show, a group of hackers taking on a major corporation, is something that also happens in real life. I fear these kinds of cyberattacks and cyber physical warfare will only become more common. Mr. Robot paints an accurate picture of this world and also shows the possible consequences of a successful hack.'

'We live in a world in which several major organisations collect a wealth of information about each and every one of us. That is part of the reason why I do not have a Facebook account and am careful about how I use the internet. When you connect your Gmail account to your Android phone and use Google's search engine, the company will know virtually everything there is to know about your behaviour. This show gets people thinking about whether they want all their personal information to be in the hands of a few major commercial organisations.'

Stray observations

- 'Darlene, the main character's sister, writes the code to take advantage of a leak in a program in just one hour.
 The show pushes the limits of credibility with that. I am not saying that it is impossible to write a script like that in such a short time, but it is borderline unbelievable.'
- 'The hackers spend a lot of time in the dark, alone, sitting behind their computers. Drug abuse is also a part of the show. That is a stereotype, although there are definitely real-life parallels. Hacking is not a nine-to-five activity. Instead, you are unrestricted by time or location. When I keep working on something in the evening, I also regularly find myself sitting in a poorly lit room at two in the morning. The only difference is that my drug is coffee.'
- 'The hackers' collective fsociety meets in an abandoned arcade. That is not very believable. I do not think many hackers have a physical place to meet. What is realistic is that they do not use their own internet connections to initiate a cyberattack.'
- 'The main character, Elliot, suffers from delusions and depression. This allows the show to play around with what is real and what exists only in his head. Elliot's condition also obscures his moral boundaries. That provides an interesting perspective on the morality of hacking. The DACS group I am part of works with large data sets. In theory, we should ask every single person for permission to use their information. We consider ourselves to be the good guys in the world of cybersecurity, but this does show that there exists a substantial grey area in what we do.'

POP CULTURE

Text: Rik Visschedijk





The 5 second rule

Do you ever take the time in your busy life to wonder about everyday phenomena? Things that are self-evident to us, or just a handy trick, perhaps? Nevertheless, there is always a scientific explanation for such phenomena. In Everyday Science a UT researcher sheds light on an everyday topic.

Tekst: Rense Kuipers Photo: Shutterstock

It is the perfect excuse for the gluttonous: if you drop a piece of food, you have five seconds to pick it up and put it back in your mouth without endangering your health. What is the scientific truth behind this 'rule'? Jai Prakash, associate professor of Biomaterials Science and Technology, has the answer. 'It should not be a general rule, that much is certain.' According to Prakash, there are too many variables involved. 'Think of, for example, the surface, the type of food, its texture and wetness, the amount of dust particles on the floor and, of course, the time the food actually spends on the floor.' Scientists all over the world are still unsure about the veracity of the five-second rule. Prakash himself calls it 'plausible, but you should still use your common sense.' 'A slice of bread, for example, is fairly dry but also porous. That makes it a very attractive surface for bacteria to attach to. If you drop a slice of bread on the floor, I would not take the risk.'

The same does not go for a cookie or a piece of fruit, Prakash believes. 'Especially when it has a hard surface, you can always shake, wipe or wash any dust off it.' Food that still has to be cooked is also safe, says Prakash. During the cooking process, the high temperature kills off any bacteria anyway.

'This rule is definitely a western cultural phenomenon,' Prakash says. 'In my home country of India, we would never eat anything that has touched the floor. Here, people do not think twice about putting a pacifier back into their baby's mouth after it was dropped on the ground. Ironically, they may actually



put it in their own mouth first to 'clean' it.'

Because bacteria are commonly found on dust particles, Prakash believes that an environment such as the floor of the UT's NanoLab is a safer place to leave something than your own kitchen drawer. Perhaps even for several days. 'Generally speaking, a few bacteria are not that much of a problem,' Prakash laughs. 'They are all over our hands anyway, so there is no escaping them. Besides, any bacteria you ingest help boost your immune system.'

Brain crime

ur brain never lies when it comes to recognition. Never say 'I have not seen that woman before in my life' when you actually have, at least not if you are having an EEG made of your brain at the same time. Whether you want it or not, when you look at a picture of someone you recognise, your brain produces electrical waves that confirm the recognition within three hundred milliseconds. This so-called P300 peak can be clearly seen with an EEG, which is helpful when you want to know if someone is telling the truth.

However, it is also useful for criminals who want to know where you live, who you know or what your PIN code is. All they have to do is show you some images and numbers and your brain does the rest. 'Yeah right,' you might think, 'how big is the risk that someone forces me to wear electrodes on my head?' Well, if you are into online gaming, chances are that someday you will transmit your brainwaves across the Internet yourself.

EEG is a hot topic in the gaming industry. More and more EEG headsets for consumers are being released on the market. They no longer look like dorky shower caps full of electrodes. Instead, these are cool gadgets that allow players to operate their game's protagonist without using their hands. They can also help the wearer improve their concentration or visualise their 'inner zen'. Many of these claims are pure nonsense and it is not uncommon for a headset to register your frown instead of your brainwaves. Nevertheless, the possibilities for controlling game characters are promising, especially when combined with eye tracking technology.

There are also dangers inherent to this technology. A research team made up of members from the University of Oxford, UC Berkeley and the University of Geneva gave people a popular EEG headset (Emotiv Epoc), which retails for a few hundred euros. While executing a task, they were shown images of people, bank logos, dates of birth, towns and individual numbers. Based on the test subjects' P300 peaks, the researchers were able to determine with a fair amount of accuracy where these people lived, whom they recognised, which bank they used, their date of birth and the first digit of their PIN code. The question is whether game developers and players are aware of these dangers. Admittedly, it is great fun to shoot down virtual opponents using nothing but your brain. Yet, like with phishing, botnets, Trojan horses, computer viruses and other forms of cybercrime, the biggest danger is our own ignorance.

Enith Vlooswijk

Science journalist

INTERNET GIANTS CONFIRM OUR WORLD VIEWS

Filter bubbles, a threat to online democracy?

Who determines what you see online? You? Or are you merely a puppet in the hands of internet giants such as Google and Facebook? With the help of clever algorithms, these organisations know exactly what you are looking for and they are more than happy to put you in a 'filter bubble', your own world of information designed to reaffirm your world views. UT researchers Djoerd Hiemstra and Jan van Dijk shed light on this phenomenon.

> or a long time, Google's search results questioned whether the Holocaust actually happened. The first four results of a search for connections between vaccination and autism only contain websites that support this disproven theory. Computer scientist Djoerd Hiemstra believes this to be a disturbing phenomenon, as is the fact that Google automatically completes queries. 'Perhaps this is mostly because these are businesses out to earn a profit. People pay large sums of money for ad campaigns and Google rewards them for it.' In the past, when someone searched for 'Did the Holocaust happen', Google would show an article from the Neo-Nazi blog Stormfront that listed ten reasons why the Holocaust never happened. Because Google itself did nothing against this, The Guardian journalist Carole Cadwalladr took matters into her own hands late last year. In her own words, she used 'the only language that Google understands: money.' By paying a large sum for her own Google AdWords campaign, she managed to elevate the Wikipedia page on

the Holocaust to the top of the search results, instead of the Stormfront blog.

Hardly any responsibility

'Is there nothing else Google can do?' Hiemstra wonders aloud. 'The company hardly accepts any responsibility and does not take a moral stand.' He does believe that clever search algorithms can be useful, though. 'When you have hundreds of friends on Facebook, you are probably more interested in your friend's status updates than those from a former classmate you knew twenty years ago. What is going wrong, however, is that people are being put into a bubble because they are commercially appealing.'

Suddenly, a Facebook timeline takes on an entirely different meaning. Professor and media sociologist Jan van Dijk agrees: 'If you are an Ajax fan, you will mostly see content about Ajax. The social medium only reinforces the things you surround yourself with and where your interests lie.' He does not believe that to be a good thing. 'It only serves to exacerbate social polarisation.'

RESEARCH



Text: Rense Kuipers Photo: Gijs van Ouwerkerk

These are not absolute bubbles, Van Dijk states. 'Just look at the American presidential election; you cannot avoid also seeing content from the other party. It is true, though, that certain opinions that fit well within your world view are reinforced. That is known as 'confirmation bias' and it is something we have been doing since the dawn of time. You automatically look for whatever suits you most.'

Secrecy

Hiemstra and Van Dijk are also critical of the lack of transparency from major organisations such as Facebook. 'They are secretive,' Van Dijk says. 'Their algorithms are corporate secrets and form key aspects of their earning model. While they know everything about their users, users know hardly anything about Facebook.' Hiemstra notes that both Facebook and Google are constantly changing their algorithms. 'This is an act of deliberate secrecy designed to keep people from manipulating the system and protect their revenue streams.'

The corporations are not entirely to blame though, Van Dijk feels. We should also question our own actions. That is why he mentions the term echo chambers. 'The difference with filter bubbles is that we create echo chambers ourselves by moving in the same circles and repeating the same opinions over and over again. It is rare for someone to deliberately look for information that does not confirm their views.' Van Dijk: 'People should know how to distinguish between facts and fiction online, but is it fair to expect that of them? There has to be a way to tell the two apart. Considering the enormous quantity of information we have to process these days, I am beginning to think that we are simply saturated.'

Federative search engines

In order to see the forest for the trees of commercial interests, Hiemstra researches the possibilities of 'federative search engines.' These not only show Google's search results, but also those from other search engines. 'You can be sure to receive relevant search results from several sources, which helps to dramatically weaken the monopoly position of an organisation such as Google.'

Returning to the core principles of the internet might also be a good idea, Van Dijk and Hiemstra believe. Hiemstra: 'Think of internet fora for example – these are commonly overlooked today. People flock to communities where they feel safe and heard. At least they are free to choose their own community.' Van Dijk: 'Although there is no shortage of discussion on social media, there are no leaders involved in any of it. Everyone talks over each other. If you were to use moderators, these discussions might actually lead to something.'

Although both scientists view the filter bubble as a problem, Van Dijk believes there will always be people who do their best to discover the other side of a story. 'Filter bubbles are not the end of online democracy,' he says. 'Although it is high time that we take a step in the right direction.' •

'Users know hardly anything about Facebook'

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Safe drinking water for developing countries

Together with partners, UT membrane scientists headed by Erik Roesink and Wiebe de Vos, have developed a unique membrane to purify drinking water. The membrane not only removes water-borne bacteria, but also inactivates viruses. The simple design combined with state of the art technology is cost-effective and easy to operate.



RESEARCH



Text & photos: Hans Wolkers

his is our newly developed membrane,' says PhD scientist Terica Sinclair of UT's Membrane Science and Technology cluster. 'With a little more development, this could change the lives of many people in developing countries in the future.' She holds a bundle of white, hollow fibers in her hands. Each fiber roughly measures half a millimeter in diameter.

For several years, chemical engineer Sinclair has been working at Wetsus, European centre of excellence for sustainable water technology in Leeuwarden, to develop a simple and effective way to purify contaminated drinking water from water-borne pathogens. And with good reason. At the moment, one in ten people doesn't have access to clean drinking water, a staggering 780 million people worldwide. Contaminated water is responsible for the death of over 5000 children every day because of water-borne bacterial or viral infections. Without any action, this problem will dramatically increase over time due to climate change and a growing world population. Sinclair is highly motivated to help solve this problem: 'After the earthquakes in Haiti, I worked there as a volunteer and I saw the huge need for uncontaminated water with my own eyes,' she says. 'I decided to dedicate my career to contribute to a solution of the problem.'

Simple technology

Purifying drinking water using membranes is a recognized method. Bacteria can easily be removed by the principle of microfiltration, a simple technology where water is forced through a porous membrane containing tiny holes of about $1 \,\mu$ m, smaller than most microorganisms.

Usually, gravity delivers enough pressure to pass the water through the membrane. Bacteria are too large to pass through the membrane holes and are contained. However, most viruses are not. To remove viruses, more sophisticated **.....**

'Over 5000 children die every day because of contaminated water'

so called ultra-filtration membranes are needed. Pore sizes are as small as 10-20 nm. But to pass water through the tiny holes of such a membrane, a high pressure is needed. This can be delivered by, for example, powerful pumps. For many developing countries, however, this is too complicated and too costly. Flawless operation requires specialized technical knowledge and pump maintenance. Therefore, a different membrane design was required: low cost and simple technology to guarantee effective operation.

Anti-viral coating

To develop a simple, but effective membrane capable of removing viruses, the membrane scientists dug into piles of literature. They discovered that walls of surgery rooms were painted with anti-viral polymer coatings. They wondered if similar coatings could be used to cover their membranes to make it an effective anti-viral barrier.

The first challenge was to attach the polymer coating to the membrane surface. Because the membrane and the coating have opposite electrical charges, attaching the coating to the



membrane was relatively easy: simply dipping a flat sheet membrane into the positively charged polymer solution was enough. For tube-shaped membranes, the polymer solution was flushed through the hollow membrane fibers or blended in the polymer solution that is used to make these hollow fiber membranes.

By adding copper and silver-based nanoparticles to the coating, the membrane became even more deadly for viruses and bacteria. At the same time, these nanoparticles worked as anti-fouling, thereby preventing growth and obstruction of the membrane filter by other microorganisms.

Proof of principle

With the prototype complete, the team was ready to start testing the first membranes for the ability to inactivate viruses. 'I'm a chemical engineer, not a virologist,' says Sinclair. 'Therefore, this was a tough part, but eventually we managed to get consistent results and showed the proof of principle: our idea worked!' Sinclair used bacterial viruses to test her coated membrane for virus inactivation. She passed water containing these 'surrogate' viruses through her membrane and tested the water before and after filtration for the presence of these viruses. Her experiments proved that the membrane removed 99.9% of the viruses.

Sinclair puts her findings into perspective: 'Our results are of course limited by the tools and methods we used. But still this was a great moment!' Now the team could move to the real stuff: together with the Department of Virology of RIVM the membrane will be tested with actual pathogenic viruses like the rota- and adenoviruses as well as hepatitis A. These tests are necessary because the proof of principle was demonstrated for one 'surrogate' virus only. These bacterial viruses might be easier to remove than 'real' pathogenic viruses. 'Only such tests mimicking the real-life situation can give conclusive evidence that the method will also work in the field,' states Sinclair.



'The main challenge is to keep it affordable'

Low cost

Within months all tests will be completed, Sinclair expects. Then the membrane has to be fitted into a module, containing a bundle of membrane fibres, that is easy to operate and above all: of low cost. 'The manufacturer will simply glue a bundle of fibres into a plastic holder and assemble it,' Sinclair explains. 'When this model survives the field tests and operates in a good way, mass production will be started.' The main challenge will not be the efficiency of the membrane unit, but keeping it affordable. The engineer expects that within months there will be working units in the field. Despite the great success of the team's efforts, Sinclair sees the development of the virus-inactivating membrane as just a temporary answer to the need of clean water in many developing countries: 'The ultimate solution is a good working water and sanitation system,' she says. 'If we manage to eventually develop a successful membrane, it will hopefully cover the needs of many people and supply them with safe drinking water until such a sanitation structure is established.' •

Financially the project was made possible by Waterinstitute Wetsus and the companies NX Filtration, WLN, AquaNirvana and Berson.



Text: Michaela Nesvarova Photos: Clear Flight Solutions & Shutterstock

It's easy to be impressed by Robirds just by looking at them: They are robotic birds that can fly using wings. They look and move so 'real', they even fool their living counterparts. However, their visual appeal is only one of the reasons people are wowed by them. What makes this piece of technology so unique? The answer lies in the Robirds' ability to mimic nature.

Robirds: Technology mimicking nature

imicking nature is the true strength of the Robirds' developer, the UT spin-off Clear Flight Solutions. 'Our expertise doesn't cover only Robirds and other drones, but most importantly nature. This connection of novel technologies and nature is what makes us stand out,' says Robert Jonker, who is the co-founder of Clear Flight Solutions, together with the company's CEO and a UT alumnus Nico Nijenhuis.

Why?

Let's start with the basics. Robirds are remotely controlled robotic birds of prey used for bird control, for example, at airports, near oil and gas companies, at waste management sites or within agriculture. In other words, they are very special drones used as very high-tech scarecrows. Although, unlike scarecrows, they actually work. Why? Thanks to their silhouette and behavior.

'Birds are incredibly clever animals and they learn very quickly. If you set up something to scare them off, they get used to it; they soon realize it's not a threat,' explains Robert Jonker. 'What birds never get used to are their natural threats: predators. And in order to trick them into thinking that Robirds are real birds of prey, we need to mimic nature as well as possible. For instance, birds know that predators that only glide and don't flap their wings are not hunting. We therefore train our pilots to very accurately mimic natural behavior and we make sure that Robirds have realistic weight and wing beat frequency.'

Besides accurate behavior, the Robirds' appearance is of course crucial. Even though existing Robirds are painted to fully resemble living birds, it is their silhouette that does the trick. 'Their color is not important, because our birds represent falcons that hunt all over the world, meaning they have many different colors,' clarifies Jonker.

How?

Robirds can fly automatically, but not autonomously, and so a pilot always needs to be present and have a visual line

of sight. The company has several practical reasons for this. Firstly, the technology that drives Robirds is not yet able to automatically see and recognize birds and consequently pretend to hunt. Secondly, law doesn't allow for automatic flight without a pilot being present, which is why current Robirds aren't even equipped with cameras.

How do Robirds stay in the air? They truly don't have any propellers. It's all in the wings, Jonker explains: 'Robirds use flapping wing flight as a means of propulsion. The wings make a unique movement, as if they were rowing through the air. There is an electrical motor inside the bird. This motor drives a gearbox, which allows the wings to make the flapping movement.'

Main challenges?

It might sound easy enough, yet making a Robird has been extremely challenging, as Nijenhuis can confirm: 'Our end solution looks simple, but it is not. It is difficult to model a wing, because it constantly has a different shape. If you look at the three dimensional flapping flight, you see that there are at least thirteen independent variables to it. These are too complex to control. Most difficult part is to bring them into something that you can control and understand.' 'If you look at it from a strictly scientific point of view, we don't accurately mimic natural flapping. That would require the entire bone and muscle structure of a bird and we simply can't create that the way nature does. Which I find very fascinating, by the way,' says the company's CEO. 'Moreover, birds fly in speeds where normally you have a transitional flow boundary layer. When you are within those speeds, you want to trigger a turbulent boundary layer as soon as possible because the flow is so poorly defined. Birds do this with the individual hairs of their feathers, which act as tripwires for the flow. We do it with the roughness of the surface of the wings.' 'Material is therefore another issue,' points out Nijenhuis. 'Not only that our birds need to be a little rough on the surface, our wings need to be very flexible, able to twist and flap. So we need a light, flexible, little rough and strong material. That is a challenge.' Solution? The Robird's body is all 3D printed

and made of glass reinforced nylon, while its wings are made of foam.

How about the inside of a Robird? What is hiding under 'the hood'? 'There is an autopilot, sensors and most importantly GPS and a barometer to see how high the bird is and to ensure it stays within the specified geo-fence. This geo-fence is not only horizontal, but also vertical and the bird needs to stay within it, because safety – especially at airports – is the most important aspect,' answers Jonker. 'The head of Robirds is hiding a simple battery. Robirds are able to fly about twelve minutes on one battery, but we almost never fly them longer than five minutes, because that represents the natural behavior of falcons.'

> 'Robirds look so real, they even fool their living counterparts'

The future?

'Eventually we want our Robirds to be automated and hopefully also autonomous,' says Nijenhuis. 'We are still far away from this goal, but that is where our technology needs to go. We are involved in research on this topic. This includes cameras fitted into the birds' eyes, ability to automatically detect birds and also linking the Robirds to air traffic network. The University of Twente is still one of our main research partners.' •



Twente Water Tunnel

It might remind you of a big blue lava lamp, but the Twente Water Tunnel is in fact a highly specialized and unique facility, which occupies three floors of the Meander building at the UT. Located in the lab of the Physics of Fluids group, this eight meters tall circular setup is used for various experiments related to the study of bubbles in turbulent flow. Using an active grid, intense turbulence can be created inside the Twente Water Tunnel in order to study how light particles move and how their movement affects the turbulent flow.



Text: **Michaela** Nesvarova

Photo: **Arjan Reef**

The results of the experiments conducted in this lab are useful particularly for the field of chemical engineering, and for our understanding of atmospheric flows, such as the behavior of dust particles and rain droplets in clouds. The experiments are done with moving cameras located on the side of the tunnel. To make particles and objects inside the tunnel easier to track, researchers also use lights and high speed lasers, which is why protective goggles are necessary. The tunnel can be filled with water from a big reservoir on the ground floor. The water can circulate clockwise or counterclockwise, which produces an upward

or downward flow in the measurement section, thanks to which scientists can study both heavy and light particles.

Some of the main people affiliated with the lab are Professors Detlef Lohse and Chao Sun, and postdoc researcher Varghese Mathai. However, the lab is also open to a number of PhD and Master students and is home to various other equipment. •





Text: Michaela Nesvarova Photos: Christiaan Krouwels



A digital firefighter

UT ALUMNUS ROGIER VAN WANROIJ KEEPS OUR DIGITAL SOCIETY RUNNING

His childhood dream of becoming a firefighter didn't quite come true. When he goes to work, he wears a suit, not a firemen's uniform, and flaming buildings are not a daily occurrence for him. Yet, he does fight fires. They might be less physically violent, but they are equally burning and capable of disrupting our entire society. UT alumnus Rogier van Wanroij is a cyber security expert working at the Dutch Ministry of Security and Justice.

ur task is to keep the Netherlands stable and safe. Enhancing the stability of the Dutch society in the digital domain is crucial for that, because digital means are essential for our society to keep running. Critical services like electricity or our financial systems need to keep working,' says Rogier van Wanroij. 'That is why we call ourselves the "digital firefighters".'

If this UT graduate were in fact a fireman, visiting his workplace would probably be much easier. At a fire station you'd not need to undergo any registration, several ID checks and scans, all of which is necessary if you wish to get to Rogier van Wanroij's office. And understandably so. After all, his office belongs to the National Coordinator for Security and Counterterrorism (NCTV), responsible for ensuring that the Netherlands remains safe.

Managing cyber attacks

'I'm a Deputy Manager of Expertise and Advise at the National Cyber Security Center, which is part of the NCTV,' specifies Van Wanroij. 'The main objective of our department is to increase knowledge and awareness of cyber security. We keep track of current developments and threats, provide specific guidelines, give presentations and collaborate with many public and private partners, including universities and research institutes – University of Twente as well.' This could sound as a 'regular boring office job',



but the ministry employee assures me that it's anything but. 'This job is very fast paced and exciting. I never know what the week will bring,' he describes. 'We're part of the crisis management infrastructure, which means we are tasked to manage major incidents. In particular, we coordinate cyber security incidents, such as the recent WannaCry ransomware attack. If an attack happens, we immediately have to contain it, assess the level of the threat, because it could damage the country's critical infrastructure. Suddenly we could be without electricity or money.'

A growing threat

Could that happen? Should we be worried? 'Yes, we should take these threats seriously. Professional criminals are becoming increasingly better organized and are using advanced digital attack methods. They are becoming a growing threat to the digital security in the Netherlands. Yet, if it comes to cyber security, there are many easy things everyone can do to protect themselves. Simple backups, for example,' says Van

'Our entire society runs on digital means'

Wanroij. 'Everyone should pay attention to their cyber security and realize it will and should cost some money. We protect our physical possessions with locks on our doors, and so we should also protect our digital ones. Countermeasures are no guarantee you won't have problems, but they help to deal with them.'

A board level issue

As the UT alumnus points out, cyber security should not be an afterthought: 'It should be a board level issue and one of the main priorities in every organization. But getting this message across to the public is a challenge. It used to be viewed as a technical issue, something for the IT department, but the truth is that our entire society runs on digital means.' That is why it's vital to look out for any cyber security threats and inform organizations as well as the public. Because everybody is responsible for their own digital safety.

'One of today's biggest threats are professional cyber criminals,' explains the expert. 'They want to make money and they are very good at innovating their 'business processes'. In fact, they are much faster at innovation than regular companies, as evidenced by the advancements in ransomware. Other cybersecurity dangers relate to state actors. Don't underestimate the effects of cyber espionage. Digital attacks are nowadays used to influence democratic processes.'

Improving our society

Dealing with such criminal activity is very difficult though, because, as Rogier van Wanroij mentions, the world of cyber security is constantly changing. 'Both problems and solutions in this domain are not clearly defined. It's therefore challenging to bring everyone together and improve it. That makes my job complex, but also interesting. I'm very happy to work here with so many people, who are truly driven to improve society. It gives my life purpose.'

Improving our society was indeed the main reason why this Computer Science graduate began a career in the field of cyber security. 'When I finished my studies in Twente in 2000, I realized I wanted to help make our society better,' he says. 'I'm proud of what our organization has accomplished in the past few years. We still need to do more, but we've changed people's view on cyber security. I see that there has been a change for the better and I'm proud to be part of that change.' •

Hacking your voice

lot of technical-scientific research is focused on combating the negative effects of previous research, such as obesity and the plastic soup. That is particularly true for the field of cybercrime and the growing demand for cyber security. As with 'regular' crime, a lot of cybercrime can be prevented with common sense, attentiveness and regular maintenance of your digital security measures. Science also contributes to this form of security. No one with a shred of integrity can oppose this development, because crime is evil.

It is much harder to morally evaluate artificial intelligence (the theme of the previous edition of Science Magazine; I am a slow thinker). Artificial intelligence creates new opportunities that may not be illegal, but still have the potential to be socially disruptive.

The Canadian organisation Lyrebird, for example, is developing technology to have the voices of famous people say random lines. In a demonstration on SoundCloud, 'Trump', 'Obama' and 'Hillary Clinton' appear to discuss this technology. The timing is still a bit off and there is some rattling and static, but the voices sound lifelike and their intonation is fairly realistic. 'Trump' sighs: 'This is huge, they can make us say anything now, really anything.' That is a clever observation. Ever hopeful, 'Obama' says: 'The good news is they will offer the technology to anyone.'

A sympathetic move, it would seem – but is it really? The current fake news is still relatively easy to unmask, but what if you can make any public figure say whatever you want in a way that is indistinguishable from 'the real thing?' It seems only a matter of time before this becomes a reality. When your voice has been hacked, you lose all control over what you say. While some politicians currently dig their own political graves with what they say, soon they will also have to worry about what others are making them say. For the public, the line between the truth and a lie will become even blurrier.

Why would you make this technology publicly available? In a statement on its ethics page, Lyrebird claims that it wants to warn of the dangers this technology poses. That does not sound entirely genuine, however. After all, one does not go around selling beer to warn of the dangers of alcohol abuse. In any case, this technology is on the rise and will pose another new challenge to our cyber security.

Wiendelt Steenbergen

Professor of Biomedical Photonic Imaging

SÉVERINE LE GAC: 'FAR BETTER PREGNANCY RATIOS ARE WITHIN REACH'

The culturing of human embryos

Miniature reactors in chip format mimic human tissue and organs better than ever before. 'Research on culturing human embryos is now ready for clinical tests,' says associate Professor Séverine Le Gac of the Amberteam (Applied Microfluidics for BioEngineering). 'We believe that with the help of human-like culture microchambers far better pregnancy ratios - now lying around a poor 30% success rate - are within reach.'

rgan-on-a-chip platforms are a promising strategy in research, says the leader of the Amber-team. Drugs can be tested more efficiently and, in addition, the use of animal experiments can be reduced. In a project concerning Assisted Reproduction Technologies (ART), microfluidic devices are being developed to culture embryos before implantation. These devices include culture microchambers measuring 500-2000 µm in diameter, only some five to twenty times the diameter of a human hair.

They are made of PDMS, a common polymer material, and bonded onto a glass substrate. Mouse embryos are introduced therein via reservoirs and microfluidic channels. 'Embryos are seen to develop faster and with a higher developmental rate

'Research on culturing human embryos is ready for clinical tests'

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in these tiny chambers,' Le Gac says. 'Since recently, real-time monitoring of single embryos is possible.'

Monitoring of individual embryos

She explains the particular strength of this type of organ-ona-chip research: 'We can fabricate a series of identical reaction platforms and chambers. There we test the individual embryos under identical conditions, monitoring them along the way.' The pre-clinical tests to follow will be done in collaboration with Max Planck Institute and CeRA (Centrum für Reproduktionsmedizin), both in Münster, and the IVF Center of the VUMC Amsterdam. Le Gac says: 'We have a good chance to decisively improve current low success rates in IVF, now lying on a poor 30%. The quest is to refine selection procedures for the embryos to be implanted. The better their quality, the bigger the chances for a pregnancy and the birth of a healthy baby.'

Breeding cows and horses

Related to this work, Le Gac mentions a new project on veterinary research, on breeding cows and horses, in collaboration with the department of veterinary sciences of Utrecht University. Here, in a microfluidic device, the oviduct structure is mimicked very lifelike.

RESEARCH

Text: **Egbert van Hattem** Photo: **Rikkert Harink**

'We still use plastic channels in these organ-on-a-chip devices, but we are now able to layer the channels with cells characteristic of the oviduct. We mimic the travel of the sperm cell through the oviduct: a crucial stage in the reproduction and fertilization process,' clarifies Le Gac.

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'We have already gained first insights. We are quickly learning in what subtle ways embryos are in danger of getting damaged or hampered in growth. These fundamental insights may well be of importance to further improve human IVF strategies.'

Nanomedicine penetration into tumor cells

The Amber-team works on various other exciting research topics too, such as the surprising, and imaginative, work on nanomedicines in breast tumor tissues. Here ultrasound comes into play. This work is done in close collaboration with University of Twente researchers dr. Jai Prakash (Biomaterials, Science and Technology, BST) and Professor Michel Versluis (Physics of Fluids, PoF).

'A multidisciplinary approach is requisite, in order to make decisive contributions,' Le Gac believes. 'We are testing next generation drugs and treatment strategies by making our organon-a-chip models and microfabricated devices more advanced. We add new features and functionalities to them. Here the complementary expertise of Michel Versluis is key, to enhance nanomedicine penetration into tumor cells. We study in what way ultrasonic stimulation can be employed. Surprisingly, ultrasound stimulates deeper and thus more effective penetration of targeting nanomedicines straight into tumor tissue.'

Very fascinating results

Very realistic breast tumour models and blood vessel environments are created in these organ-on-a-chip devices. Their interactions with the bubbles and the ultrasound waves can be studied on the spot. 'We expect the penetration of the drugs to be deeper, but we yet need to identify the optimal parameters,' Le Gac says. 'First results are promising and, as you can imagine, very fascinating.'

The contribution of dr. Prakash of the BST Group is crucial as well, Le Gac adds. 'We work with realistic nano-sized drug samples in these experiments. The BST Group provides us with drug samples currently used in practice. Only by doing so we can realistically hope to contribute to novel future breast cancer treatments.' •

Second generation organ-on-a-chip research

At this very moment, thirteen active researchers are involved in the Applied Microfluidics for BioEngineering (AMBER) team, part of Mira Research Centre, led by Séverine Le Gac. 'Especially more bachelor students are involved,' she points out. 'We are gradually entering into a second generation of organ-on-a-chip research. Master and bachelor students work on complementary themes of the PhD and post-doc topics. For them it is a great opportunity to work at the very heart of research. They feel a real thrill that something great might happen any moment.'



Energy: The road to empowerment

Text: Michaela Nesvarova Photo: Shutterstock If you live without electricity, life can be difficult. Plenty of people in Africa could testify to this - many children skip school and many women risk their safety, simply because they need to go out and collect wood, for instance. Providing them with electricity should therefore make their lives easier. It's not as simple as that, though.

> oor people aren't a homogenous group. They have a lot of different needs and habits. This applies to the use of energy as well. Our goal is to provide evidence that energy use affects people differently, especially that it has a different effect on men and on women,' says Nthabi Mohlakoana, coordinator of the UT research project titled 'Productive uses of energy

in the informal food sector in Rwanda, Senegal and South Africa'.

This project falls under the ENERGIA Gender & Energy Research Program, which is led by Joy Clancy, Professor in Development Studies at the University of Twente. This large international program with a diverse team of researchers, including Prof. Hans Bressers of CSTM, aims to

'Energy has a huge effect on people's lives'

prove that energy use has a significant gender aspect and that energy policies should take this aspect into account, because the same energy services have different outcomes for men and for women. Particularly if we talk about poor rural and semi-urban areas in developing countries.

Opportunities for men and women

'Our project looks at three countries: Rwanda, Senegal and South Africa. In these countries informal economy is one of the main forms of livelihood, impacting a lot of people,' continues Nthabi Mohlakoana. 'We focus on the informal food sector, because it is dominated by women; to them it is the primary source of income. They use both traditional and modern energy for cooking and selling food and we want to know: How does energy contribute to better livelihood of these women?'

This research is by no means a theoretical exercise. Its results are meant to directly influence policy makers in the involved countries. 'We want to find out what people actually need. We don't want to make assumptions and just provide one solution for everyone, because that doesn't necessarily work. We want to know for whom the energy services are really beneficial and what interventions can be made, so we can create opportunities for both men and women,' emphasizes the CSTM researcher.

Electricity could kill the business

In order to help the locals, the project includes the locals. In other words, the data come straight from field research, from asking people about their needs. Nthabi Mohlakoana herself has recently returned from Africa, where she has learnt more about how the informal food sector works and how important it is to ask questions before we act.

'When we speak of informal food sector in Africa, we usually refer to people cooking and selling food on the side of the road. For example, many owners of these unregistered enterprises use traditional means such as wood or charcoal, to barbecue meat and cook other food. If they should replace that with electricity or gas stoves, they would lose customers because their food would suddenly taste different. Providing them with electricity could, in this case, kill their business.' Solution? 'It's all about planning together with the people,' thinks Mohlakoana. 'Many municipalities move the food traders to one central location. which they see as a proper place where they can do business and don't pollute streets. But these places are often far away from roads, far away from customers, and so the traders leave them. If there was a mutual planning, results might be different. I saw a great example in Cape Town. A private investor built stands and a communal fireplace for local traders and this worked nicely: it provided a safer space and led to less pollution, because people really used this solution.'

Women empowerment

Making sure that the provided energy services are actually used is extremely important to the project. After all, its main goal is to empower locals, especially women. 'Empowerment comes in many ways,' says Mohlakoana. 'You can feel empowered thanks to electricity, because then you don't have to go out and collect wood or because you can stay out at night.'

Both of these examples relate to safety, which is one of the main gender aspects of energy use. 'Women who cook on the side of the road need to leave before sunset, otherwise they are a target. They could be robbed or become victims of violence. This gives businesses run by men a big advantage. All because of their gender. A simple thing like communal electricity lighting would help with this issue,' points out Mohlakoana. 'This shows the importance of gender planning. You might think 'it's just energy, what kind of impact could it have', but it has a huge effect on people's lives.' •

IT'S ALL ABOUT THE MONEY

Who are they?

Eve on Air develops the Eyon1, an electronic sleuth for the detection of, among other things, explosives. The company, situated in The Gallery, was established in 2013 with the support of a TOP scheme. It was founded by former UT employees Sergey Mitko, now Chief Science Officer, and Yuri Udalov, now Chief Technology Officer. Last January, the company received a capital injection of 1.8 million euros from its shareholder Mainport Innovation Fund and some private investors, with the objective of bringing Eyon1 into the market in the course of this year. Managing Director Ewout Maaskant tells us how they plan to do this.

What is the Eyon1?

'A device for detecting very small quantities of explo-

What technology is used?

'The Eyon1 uses ion mobility spectrometry (IMS), which uses the speed of movement of an ion as a basis for analysis. If you have an air sample that you suspect contains vapours of explosives, the air sample can be ionized by shooting electrons at it. This will lead to electrically charged molecules (ions) that move at different speeds. This is what we measure. The measured speed of movement is then associated with, for example, explosive A.'

How will Eyon1 conquer the market?

'We are able to detect very small concentrations of substances in the air. Our technology is much more sensitive and much faster When are research results ready for the market? And how do you make sure that you make money? A section on the marketing of scientific knowledge.

Eye on Air

Text: Sandra Pool Photo: Shutterstock

than the technology in existing equipment. For us, this is the basis for the development of a stand-off device, a device that scans a person without touching them.'

Who are the buyers?

'Security checks are conducted at airports; they are therefore potential clients. A number of techniques can be used at airports to check passengers: metal detection, security scans and searching. One specific safety check, which was added in Europe in 2015, is important to us: scanning for traces of explosives.'

How much does Eyon1 cost?

'The exact production costs are confidential. Prices for similar screening products for airline security are between thirty and forty thousand euros per product. Such market prices are sufficient to cover the production and development costs of Eye on Air.'

What will the future bring? 'The business model of Eye on Air includes the development and sale of detection equipment. We can also license parts of our technology to third parties. Because our technology measures very small concentrations of substances in the air, the possibilities for application

When does science become valorisation?

are unlimited.'

'The role of the researcher is essential in this. The researcher must have both the faith and the drive to realise the impact on society. You have found something, but what are you going to do with it? That is where valorisation starts.'
Vincent Bloemen

Text: **Michaela Nesvorova** Photo: **Gijs van Ouwerkerk**

Easier, faster and cheaper software development

""" 'Some software systems are too large to be analyzed correctly. Take aerospace applications, such as systems operating satellites, for example. If they crash, you have to deal with very high cost problems. However, if you could properly check your satellite system before its launch, these problems could be avoided,' Vincent Bloemen explains why he's working on techniques to find all bugs in any software.

Bloemen is a PhD candidate at the UT's Formal Methods & Tools group. His research falls under the project 'Big Software on the Run', which aims to analyze software while it's running. 'Finding bugs in large software systems is very hard,' begins Bloemen. 'We need efficient techniques and high-performance algorithms – and developing those is my task.'

'At the moment it takes a lot of time and effort to check the correctness of a system. Smaller applications can be checked manually, but there is no real solution for checking big software,' continues Bloemen, whose ultimate goal is to make software development easier, faster and also cheaper. If he's successful, his method will be applicable to any piece of software, including those used to operate rocket ships or self-driving cars. 'It would be great if I could contribute to making self-driving cars safer,' he says.

To make this happen, Bloemen is using model checking. 'By automatically exploring all possible states of a system, we can quickly detect bugs and thus speed up the software development,' explains the young researcher, who has been interested in computer science since high school. 'I started programming as a teenager, but I wouldn't call myself a great programmer just yet,' he says modestly. 'I enjoy the combination of mathematics and computer science, which is why Formal Methods is the ideal place for me. It allows you to program, but also prove that what you're doing is actually correct.'

And what are Vincent Bloemen's goals after he acquires his PhD title? With a doctorate in his field, not even world-famous companies seem off limits. 'I would be interested in startups. Young companies give you more freedom, while the big ones come hand in hand with large restrictions and pressure,' answers Bloemen. 'My only goal is to ensure that I'm happy at each stage of my life.' •

Our 'Rising Star' Vincent Bloemen:

2015 cum laude Master's degree in Computer Science with honors

2016 award for the best master's thesis written at the faculty of Mathematics, Computer Science and Mathematics

2016 Best Presentation Award at the Doctoral Symposium on Formal Methods



A nose for disease

Rats sniffing out landmines, dogs detecting drugs or even intestinal cancer... the phenomenon of 'diagnostic scent' is nothing new. But there are untapped possibilities. A great many, UT professor Guus Rijnders believes. That is why the people at MESA+ are working hard on the e-Nose: a quick and cheap breathalyser test that helps with the early detection of diseases such as asthma and lung cancer. ting off the sofa. All it would take is a breathalyser test using a sensor that could be built into our smartphones. 'It would be as easy as taking a pregnancy test.'

Such DIY tests for use at home do not exist yet, but Rijnders estimates that a test device for general practitioners could become a reality in five years or so. MESA+ is not the only institute working hard on the development of such a breathalyser test. 'Some labs already use these tests,' he says. 'Existing tests can only indicate whether or not the test subject has a lung disease, but they cannot distinguish between the different types yet. Of course, there is a significant difference between asthma and lung cancer.'

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Text: **Kitty van Gerven** Photo: **Gijs van Ouwerkerk**

'An e-Nose can also detect fireworks smuggled into a stadium by football fans.'

B lood and urine tests, X-rays, ultrasounds, MRI scans... there are many possibilities to scan for diseases, but most are time consuming and costly. For that reason, they are only used after a patient has visited their doctor with physical ailments. 'Unfortunately, that is sometimes too late. Some types of cancer, such as lung cancer and pancreatic cancer, have often reached an advanced stage by the time the first symptoms present themselves – with all due consequences.'

Professor Guus Rijnders, Scientific Director of the MESA+ Institute for Nanotechnology, wonders how great it would be if there was an easyto-use and affordable device that you only have to blow on for a moment to determine whether or not you are suffering from a serious condition. Nothing like that exists yet, but the UT professor of nano-electronic materials believes it will not be long before we can test ourselves for diseases such as lung cancer or asthma without even get-





'The first breathalyser tests will probably be available in five or six years.'

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Biomarkers in your breath

The basic principle of this kind of test involves turning scent into diagnostic information, Rijnders explains. 'Although we call it scent, it is actually about the molecules in the exhaled air. Various kinds of molecules are found in everything a human body excretes, from sweat to urine and breath. If someone suffers from a disease, molecules specific to that disease are added to the mix. These are called indicators or biomarkers. Our goal is to develop a device that detects biomarkers in the subject's breath and then offers a diagnosis.' The researchers of MESA+ have already demonstrated that a device such as the e-Nose can function with the help of nanotechnology. 'It is actually a very simple device,' the professor explains. 'It consists of a series of miniscule sensors, each no more than ten micrometres in length and covered with a molecular adhesive, which are made to vibrate with piezo materials. Each of the sensors is designed to 'capture' specific molecules. The more biomarkers attach themselves to a specific sensor, the heavier this sensor gets and the more its vibration frequency changes. By measuring this frequency, we can determine whether or not the user has the disease which that specific biomarker indicates.'

No easy task

All that is left to do is to determine which molecules can be classified as biomarkers for each specific disease. That is no easy task. Fortunate-

RESEARCH



Urine test detects cancer

In a consortium that includes professor Albert van den Berg and Loes Segerink, PhD, people at MESA+ are also working on a new type of urine test that can be used to detect cancer at an early stage. With this new technology, hyper-methylated DNA can be detected in urine. Methylated DNA is seen as an important indicator for some diseases, including cancer.

According to professor Rijnders, the basic principles of this urine test are not that different from those of the e-Nose: 'This is also about detecting biomarkers.' He expects that this urine test will eventually be able to make a diagnosis with the same degree of accuracy as the e-Nose. 'If the patient has cancer, the test can even determine where the disease is located inside their body, based on the methy-lated DNA fragment that was detected.'

certain therapy is effective. It can also be used to quickly and cheaply conduct preventative studies among high-risk groups.'

Smouldering plastic

There are many other possible applications. 'Think of fire security, for example. An e-Nose can detect the scent of smouldering plastic even before the first smoke appears. It can also detect fireworks smuggled into a stadium by football fans.'

If sufficient financial assets continue to be available in the coming years – 'We partially have to rely on sponsors for this project' – there are many potential applications for this device. Rijnders is convinced that the UT will succeed in developing the e-Nose for these purposes. 'The first breathalyser tests will probably be available in five or six years. We are one of the only institutes in the world to have both the expertise and the technology necessary to develop such a sensitive device.' •

> 'It would be as easy as taking a pregnancy test.'

ly, MESA+ can count on the support of the MST hospital in Enschede and the AMC in Amsterdam. In addition to medical expertise, these facilities also provide breath samples from their patients. Meanwhile, people on campus are hard at work to develop a demonstration kit with the help of the Fraunhofer Project Center and companies such as Philips.

'It is a difficult project,' Rijnders admits. Nevertheless, he is convinced that the e-Nose will make his dream – 'using my expertise in the field of nano-electronic materials to cure people or prevent them from becoming seriously ill' – come true. More than that, even, because a hypersensitive electronic nose can do a lot more than merely diagnose diseases at an early stage. 'It might help to determine, during treatment, whether a Miriam Vollenbroek, professor of Technology Supported Cognitive Training at the UT, worked together with ZGT internist Goos Laverman to develop the Diameter. This digital diabetes coach in the shape of a smartwatch helps patients with type-2 diabetes improve their lifestyle. Recently, their invention received an award for the Best Diabetes Idea of 2017. We've interviewed Miriam Vollenbroek to learn more.

SMARTPHONE APP STIMULATES PATIENTS TO ADOPT A HEALTHIER LIFESTYLE

Diameter helps in the fight against diabetes



Text: **Marc Laan** Photo: **Rikkert Harink**

INTERVIEW

Are you happy with this award?

'The Diabetes Fund awarded us with €50,000. We can use that money to develop our idea for a smartphone app that advises diabetes patients on healthier ways to exercise and eat. This might not look like a lot of money, but it will allow us to pay another researcher for a year. We expect to have a prototype of the Diameter ready in early 2018.'

Will patients have to wear a device on their bodies?

'No, our Diameter consists of three components. First, there is a patch worn on the upper arm that contains a sensor, which automatically measures the patient's blood sugar values every fifteen minutes. This Freestyle Libre sensor, which anyone can buy, wirelessly transmits the data to the second component, an app on your smartphone. The app forwards the data to our computers. The third component is a Fit Bit wristband, which is popular among athletes as well. This measures your heartrate and registers any physical motion every minute. The patient records everything they eat in a diary. With all this information, we can predict how each individual patient will react to physical exercise and food. Our software translates that data into custom advice which is sent to the app on the patient's smartphone.'

How long have you been working on this invention?

'We started our work in 2016, although the expertise regarding diabetes and the technology involved have been developed over the past decade at the UT and the ZGT. Our Diameter app incorporates a wealth of existing knowledge about nutrition and exercise. We now use those insights to develop our coaching model.'

Will this device be available to anyone?

'We will initially use this technology for patients of the ZGT hospital. However, there are more than a million people with type-2 diabetes in the Netherlands. If our prototype works well, we will make it available to more people. The question remains who is to pay for it, because it will probably cost a few hundred euros.'

What is type-2 diabetes again?

'Type-2 diabetes is a metabolic disorder that disrupts the patient's blood sugar levels. A diabetic's pancreas does not work as it should, which causes their body to produce insufficient insulin or react poorly to insulin, with all due consequences. With our app, patients can immediately see how their blood sugar level reacts to a lack of physical exercise or the wrong diet. The app can determine on a minute-to-minute basis whether a patient has been sitting still for too long and advise them to go for a walk.'

Is it desirable to confront diabetes patients with their own behaviour in this way?

'People can only change the way they live their lives when they are aware of the fact that a healthy diet and enough physical exercise are the keys to achieving remission of their diabetes. Patients often lack that awareness. During a study conducted by internist Goos Laverman, 41% of the patients he interviewed claimed to get enough physical exercise every day. Upon examination, however, only five to ten percent of these people actually exercised enough. The others were not deliberately telling lies; they simply did not manage to exercise for an hour every day'.

Can a digital coach really change anything about that?

'Our Diameter can help patients adopt a healthier lifestyle by offering them real-time advice on exercise and nutrition. It will not be easy, however. People are creatures of habit. It is very hard to get someone to give up their eating habits after twenty years, particularly when it comes to eating too many carbohydrates. Creating that awareness also involves quite a bit of psychology. That is why we work together with behavioural scientists.

Still, many patients do become healthier, often to such an extent that their diabetes remits to a safe level, and they may no longer have to take pills, for example.'

'Behavioural change is achieved in small steps'

But the digital coach cannot do much if the patients themselves do not take action.

'It is up to you, that is right. Knowing that you should take at least ten thousand steps every day is not enough; you then actually have to do it as well. Our app proves that many people fail to do so, probably because they do not enjoy exercising. Our first goal – before we move on to unleashing all kinds of technological developments and apps on people – is therefore to transfer knowledge and create awareness. Behavioural change is achieved in small steps. Taking a giant leap all at once is too difficult, psychologically speaking. It is therefore important that healthcare professionals discuss the importance of exercise and a healthy diet with their patients, more than they do now.'



UT research into dilation of the cervix

Still a lot to discover about giving birth

In April, Master's student of Technical Medicine Silvano Gefferie (22) won the Nico Westerhof Award for his mathematical model used to simulate the dilation of the cervix. He explains that this is an area of research where 'there is still a lot to discover.'



Gefferie proudly takes his award out of his bag. The round plateau is supposed to represent a red blood cell. A transparent sphere sits on top. 'You can see the blood vessels in here,' he explains. The award represents the heart and blood vessels and is named after Nico Westerhof, a prominent physiologist who conducted extensive research into the heart and circulation system.

Parameters

The award is given out for modelling in acute care. During the conference in April, Gefferie presented his mathematical model that simulates the dilation of the cervix right before giving birth. 'That process depends on several parameters, such as the timeline and the production of oxytocin, which is an important hormone during childbirth that can also be administered externally.'

Education

The Master's student developed the model together with his fellow students (Job de Haan, Anouk Scholten, Kim Wijlens and researchers Willem van Meurs and Luísa Ferreira Bastos). The model is capable of simulating various patient profiles. 'The simulation model can be used by students or e.g. nurses as an educational tool. It simulates various situations, so you can practise the correct response to a wide range of conditions. Say that a patient is not producing enough oxytocin herself. You can then practise how to externally administer this hormone.'

The student explains how the research led to an individual optional subject. 'We want to publish an article about our model, although we do have to refine it some more before we can do that. For example, we are currently looking at a single dilation process instead of two, so some additional specification is required.'

Discovery

The control system during childbirth is completely unlike all other processes in the human body and that fascinates Gefferie. 'Whereas other hormones have an inhibiting function, the exact opposite occurs during childbirth. That is an interesting phenomenon, because it does not tie in with other processes in the body. This is an entirely new area of research for me, so there is still so much to discover.' • Science means making choices. Some lines of research become leading, while others are forgotten. Back to history dives into the archives, in search of developments with historical relevance. This time, we take a closer look at Isaac Newton, who introduced scientific reasoning in Europe but was also engaged in alchemy.

Newton, pioneer of reason or the last magician?

Text: Rik Visschedijk

Alchemists in the late Middle Ages tried to discover the secret of turning lead into gold. They worked hard to understand and to affect the proposed cycle of lead-iron-copper-silvergold. The principles of alchemy state that metals grow in the ground. With the dawn of modern natural sciences, alchemy died an unlamented death and was dismissed as mere pseudoscience.

UT science historian Fokko Jan Dijksterhuis is fascinated by Isaac Newton (1643 – 1717), who is responsible for exploring the physical concept of gravity and the mathematical concepts of differential and integral calculus. 'He is one of the founders of modern optics, physics and mathematics,' Dijksterhuis says. 'However, when you consider all his work and his research notes, the majority is about theology and alchemy. These areas of research cannot be viewed in isolation; Newton's scientific innovations are rooted in his alchemical work.'

Newton can therefore also be seen as one of the last 'magicians', as economist John Maynard Keynes described him in 1942. He conducted countless alchemical experiments in the search for the 'Philosopher's Stone', the mythical substance that would turn regular metal into precious metals. The goal was to study and achieve the reactions and transformations of materials. 'He also focused extensively on calculating the time of God's creation and the Apocalypse,' Dijksterhuis says. 'His Bible studies also led him to conclude that the Trinity is not a purely Christian concept, but rather a later doctrine. He therefore rejected it. That is ironic, since he was a fellow of Trinity College.'

More than half a century later, Antoine Lavoisier (1743-1794), Enlightenment scholar and the founder of modern chemistry, dismissed the science of alchemy. Dijksterhuis says: 'Transmutation, the process of turning one element into another, did not fit in with his new understanding of indivisible substances. He did adopt one element of alchemical science, though: adapting experiments and natural processes to suit your own needs.' We do not give alchemists their due if we outright dismiss their practices as nonsense. 'In the exact sciences, physical experiments are commonplace,' Dijksterhuis says. 'The UT is no exception. We put particles under pressure in kettles where temperature approaches absolute zero and we create entirely new nanomaterials. Like the alchemists before us, we do that by interfering with what we find in the natural world.' •

VICI WINNER ALEXANDER BRINKMAN ENJOYS TEACHING THE MOST

'l am not one to focus on titles'

In 2004, he received the Veni, in 2008 the Vidi and this year the Vici, the final and also the biggest personal research grant in the Netherlands. At 41, professor Alexander Brinkman has already peaked in terms of his research. Fortunately, working in a lab is not all he loves to do. 'Teaching students is the most gratifying part of my job.'

ne might say that the professor of Quantum Transport in Matter is 'home-grown'. He studied Applied Physics at the UT and also obtained his doctoral degree here. 'I did leave a couple of times,' he laughs. 'I spent my last year as a student in Bergen in Norway, I went to Boston for a while when I was working on my doctoral degree and I worked in Geneva as a postgraduate. I keep coming back, though. I like it here and the facilities, especially those at MESA+, are world class.'

In other areas, the researcher shows his traditional Twente colours as well. For one, he is surprisingly modest; a trait that his impressive career did not change. 'I earned quite good grades during my studies,' he replies when asked. It is not until later that he admits, reluctantly, that he was the best of his class and that a successful scientific career loomed in his future from an early age. He was equally unperturbed by his appointment to professor at the age of 35, which is quite young even by international standards. 'I am not one to focus on titles. For me, the best part is the fact that I hold final responsibility.'

Quasiparticles

Brinkman and his group focus on what he calls fundamental research. The so-called quasiparticles, which they produce for chip materials, will certainly not appear on the open market for at least ten or twenty years. That does not make his work any less exciting, though. For example, they are looking for Majorana fermions and magnetic monopoles, particles that are still only hypothetical at this point. 'Our team is engaged in a global race to be the first to create these particles.' The years of spending all his time in the lab are behind him now. He leaves that in the hands of his younger colleagues. Brinkman is in charge of overseeing affairs for the entire group. 'It would be too much to say that I miss the lab,' he says. 'But whenever I go back there, it is the highlight of my day.'

The question remains whether a lab environment would even be right for him anymore. During discussions with his students, doctoral candidates and postgraduates, he realises that they have something that he has lost himself. In his own words: 'Creativity and analytical skills, as well as an unbiased view of a problem. You lose these things over time.' He admits

INTERVIEW



'I always said I wanted to be an inventor when <u>I grew up</u>'



it is quite remarkable to discover that you are no longer the one to solve an equation the quickest or to come up with the best solution to a problem.

He has developed something else in return, however: a love for education. Brinkman now sees teaching as his main activity and it takes up around forty percent of his time at work. 'Transferring knowledge and getting young people excited, that is what I am out to achieve. That is where I can truly make a difference. It is the most gratifying part of my work.'

Culture, linguistics or science

Alexander Brinkman was born in Austria, where his Dutch parents lived for work, although he grew up in Ede. He easily passed his pre-university education and his scientific talents manifested at an early age, as did his intrinsic motivation to solve puzzles and get to the bottom of things. 'I had a knack for that even when I was young. I always said I wanted to be an inventor when I grew up.'

Still, he was not immediately sure about his academic future after finishing his pre-university education. He even consid-

'You tend to lose your unbiased view over time'

ered going to an art academy and he also had an interest in languages. This doubt characterises his wide-ranging interests. 'That is why I enjoyed my membership of the Young Academy of the Royal Netherlands Academy of Arts and Sciences (KNAW) so much. It was a chance to exchange knowledge and experiences with scientists from completely different fields.'

Brinkman ended up choosing the Applied Physics programme, 'because it is challenging and comprehensive.' He looks back on his time as a student with fondness. 'I lived on campus and I loved the student life. I was a member of the Twentse Studenten Alpen Club and I had enough time for my social life. I still cherish some of the friendships left over from those days.'

Alexander Brinkman in a nutshell:

2017:	VICI laureate
2013:	ERC Consolidator grant
2011:	Member of the Young Academy of the Royal
	Netherlands Academy of Arts and Sciences
2011:	Professor of Quantum Transport in Matter
2010:	Best lecturer of the University of Twente award
2008:	VIDI laureate
2005:	Assistant Professor in Low Temperature Division
2004 - 2005:	Maître d'Assistants, Université de Genève,
	Switzerland
2004:	VENI laureate
2003:	PhD at University of Twente
1999:	MSc at University of Twente
	(Erasmus at University of Bergen, Norway)

when the kids return from school.' They spend some quality time together during those moments, but once the kids are in bed, the laptop is usually switched on again. 'I like to work on a problem a bit more.'

Planning is a top sport

Science is sometimes compared to top sports. Does Brinkman feel the same way? 'In a way, yes. Mostly because you have to manage so many things at once. That requires excellent planning. I schedule time to write research proposals and articles, to focus on ongoing projects and for my educational tasks. I am able to maintain a proper balance between all those different activities.'

However, one passion that is sadly neglected because of his busy professional and private lives is mountaineering. Brinkman does not discriminate between a climbing wall or the Norwegian mountains he loves so much. 'That was part of the reason why I went to Bergen during my student years. I absolutely love Norway. Climbing up a mountain with your skis offers an unparalleled sense of freedom and it helps to clear your mind entirely.' Just like pro athletes, scientists need such moments of peace and quiet, Brinkman believes. 'That is the only way to truly excel in your chosen field.' •

Something new from something old

During a tour of the laboratory underneath the Carré building, where his team is hard at work trying to create non-existing particles, Brinkman reveals that he regularly attends church. That quickly leads to the question of whether or not a scientist looking for new building blocks is playing God. 'I do not see it like that at all,' the professor laughs. 'Faith is definitely a part of my life, but only on a personal level. It does not factor into these research questions. Besides, we are trying to make something new from something old, so that comparison is not entirely accurate.'

His Protestant background is also what brought him into contact with his wife. 'We met in Taizé, a monastery in France,' he says. 'We were there for a gathering with about ten thousand other high-school and university students.' She turned out to be the love of his life. Brinkman now lives near a nature reserve on the edge of Borne, together with his wife, who is a psychologist, and his two children: six-year-old son Kasper and four-year-old daughter Marit. When he is with his family, work is briefly forgotten. 'I try to be home once or twice a week



Text & photo: Gijs van Ouwerkerk

Super accurate flow meter

Newborn babies are often too sensitive to be given medicine via standard infusion therapy, because it cannot administer a fluid accurately enough. This micro Coriolis mass flow sensor, the smallest of its kind in the world, could be part of a solution. It was developed by the Micro Sensors and Systems (MSS) group within EWI. Two magnets cause the tube that holds the fluid to vibrate. The flow of fluid causes a tiny change in this vibration, which is measured using a laser. This tells the researcher how much fluid is flowing, within an accuracy of 50 micrograms per hour.



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