Eminent Talent

2007 – The thirteenth year

Netherlands Organisation for Scientific Research

Prof. D.M. (Deirdre) Curtin (1960), Professor of International and European Governance at Utrecht University. Curtin has made outstanding contributions to the development and promotion of international and European law and has developed groundbreaking visions for the governance of international organisations such as the European Union.

'Democratic accountability below par in the EU'

In recent decades the European Union has developed from being an economic union into a largely political union. Public accountability has meanwhile failed to keep pace, observes Deirdre Curtin. As a specialist in European law and governance of international organisations, she tenaciously seeks out accountability gaps and possibilities for improvement.

She is kept busy with this, since with the European Constitution under the spotlight, everyone wants to know her opinion on the replacement 'Reform Treaty'. She is succinct in her opinion. 'In terms of content there is little new, ninety percent is the same as before. Only the symbolism and rhetoric we found in the constitution have disappeared', judges the professor of International and European Governance who originally hails from Ireland. 'Whether this is better? In my opinion this new text is only capable of being properly understood by expert insiders. The structural transparency of the system leaves a lot to be desired.'

The latter is a problem that the EU frequently faces, observes Curtin. The so-called Reform Treaty lags behind everyday practice. The EU has undergone an unprecedented growth spurt in some policy areas outside the gaze of democratic and legislative control. Curtin: 'A grave matter, because as a result of this the legitimacy of the decision-making process is under considerable pressure'. She nonetheless still voted 'yes' during the referendum on the European Constitution. Because in her eyes it represented an improvement on the existing situation with some adaptation of the legal and political framework to everyday legal and institutional practices.

Scientific experts

Indignation about injustice motivated her to study law. Her interest in the EU was aroused during her studies at the University of Dublin, when she saw how strongly Irish law was steered under the influence of new directives coming from Brussels. 'Case-law was instrumental in driving social changes', says Curtin, who has now worked at Utrecht University for fifteen years. Following her studies she went to Luxembourg to work for the Irish judge in the European Court. This move to the judicial heart of the EU allowed her to familiarise herself with the european legal system. She also saw just how far apart theory and practice were. Curtin: 'The legal system is continuously busy trying to keep abreast of the rapid developments in everyday practice. And what makes this so difficult of course is that this EU practice is a hybrid entity that frequently does not fit an existing legal or political template.'

While european and national civil servants and scientific experts develop new rules, political control largely remains limited to the rubber-stamping of a document. 'There is a lack of public debate; European Member States must do far more to initiate a discussion with their citizens about the future of Europe. At present, european elections are second-rate affairs: parliamentarians are chosen on the basis of national as opposed to european issues. A 'fourth division' of non-politicians take the decisions, often behind closed doors.'

Decision making with respect to antiterrorism measures is one example of the lack of political accountability. Curtin: 'The United Nations Security Council – which is accountable to no one – decides to take measures, the European Council of Ministers adopts these without any possibility for public debate and the Member States enact these. This sometimes has far-reaching consequences for individual citizens.' The Filipino opposition leader and professor José-Maria Sison, who lives in Utrecht, discovered this for himself. When his bank assets were frozen due to 'possible involvement in terrorist activities', the European judge determined that he was not allowed to inspect any European documents that formed the basis for that decision. Curtin: 'Every person should have the freedom to demonstrate that he or she is unfairly suspected and that therefore the freezing of bank assets has no legal basis. In this respect, both the EU legislation and the political framework exhibited shortcomings.'

Fundamental research

Curtin backs up her critical observations about inadequate public accountability with empirical evidence. For example, with a number of fellow researchers she ploughed through all available comitology documents for the year 2005 in the EU database. 'Conclusion: just fifty to sixty percent of what ought to be there is actually present.' The NWO/Spinoza Award – which she considers to be recognition of the fundamental nature of her research – will enable her to expand and carry out follow-up research. The EU top needs to be prepared for closer scrutiny. Curtin: 'For example, I want to do empirical research into the role and functions of the secretariat-general of the EU Council of Ministers. That has developed into a virtually autonomous body within the European arena, particularly in the area of defence and security. Also in the area of financial security there are several large bodies that exert influence behind closed doors. I am not saying that the wrong decisions are being taken but I want to be able to establish to what extent these parties are being held accountable for their actions.'

Is there any hope then for the EU ? Curtin, surprised: 'Of course there is. I am a believer in the european project. Fortunately we no longer live in a world of purely territorial states. Many matters are arranged collectively. Our national politicians also meet each other in other networks, such as the G7 and the United Nations, where they take decisions. The good thing about the EU is that those who work within the organisation are still ultimately bound to laws and democratic control, however imperfect these are. At a european level we have measures to call them to account. At a world level we are in effect powerless, as there is no court or other accountability forum.'

Prof. M. (Marcel) Dicke (1957), Professor of Entomology at Wageningen University. Dicke discovered, for example, that in response to insect feeding plants produce specific volatile chemicals that attract enemies of their enemies.

Prof. M. (Marcel) Dicke

'Nature is a cacophony of smells'

Cabbage plants that are fed upon by caterpillars of the cabbage white butterfly produce substances that attract the archenemy of their gluttonous attackers: parasitic wasps. Describing the display card of extremely delicate chemical cues in plant and animal kingdoms is the driving passion of the Wageningen ecologist Marcel Dicke.

Marcel Dicke's research team, at the Wageningen Laboratory for Entomology, capture and analyse infochemicals of plants and investigate and study the behaviour of butterflies, parasitic wasps and other arthropods on a daily basis. 'For example, we place two plants, of which one has been attacked and one is unharmed, in a wind tunnel and release the parasitic wasps into it', says Dicke in a room full of cabbage plants and self-reared cabbage white butterflies. The scents are continuously varied in the wind tunnel experiments to determine exactly which source is responsible for the minuscule parasitic wasps choosing one plant as opposed to the other. 'Through the scents they release, plants befriend the enemies of their enemies and in doing so recruit them as their own bodyguards', explains Dicke. 'I have always wanted to be a detective who discovers how the world works. This was one of the most beautiful discoveries I made.'

A plant that is fed upon undergoes changes with considerable consequences. 'Plants communicate in their own – chemical – language', says Dicke. He discovered that in some cases as many as two hundred individual odorous compounds are released, which affect herbivores, but also predatory insects, other plants and perhaps even pollinators and passing birds. And each of them can respond to these substances in their own way. Dicke: 'Plants can only make limited use of their warning system, since the information transmitted can be used in many ways. Pollinators, such as bees, can be frightened off by the same odours. Plants are just like people, they also do many different things with the information they pick up from others.'

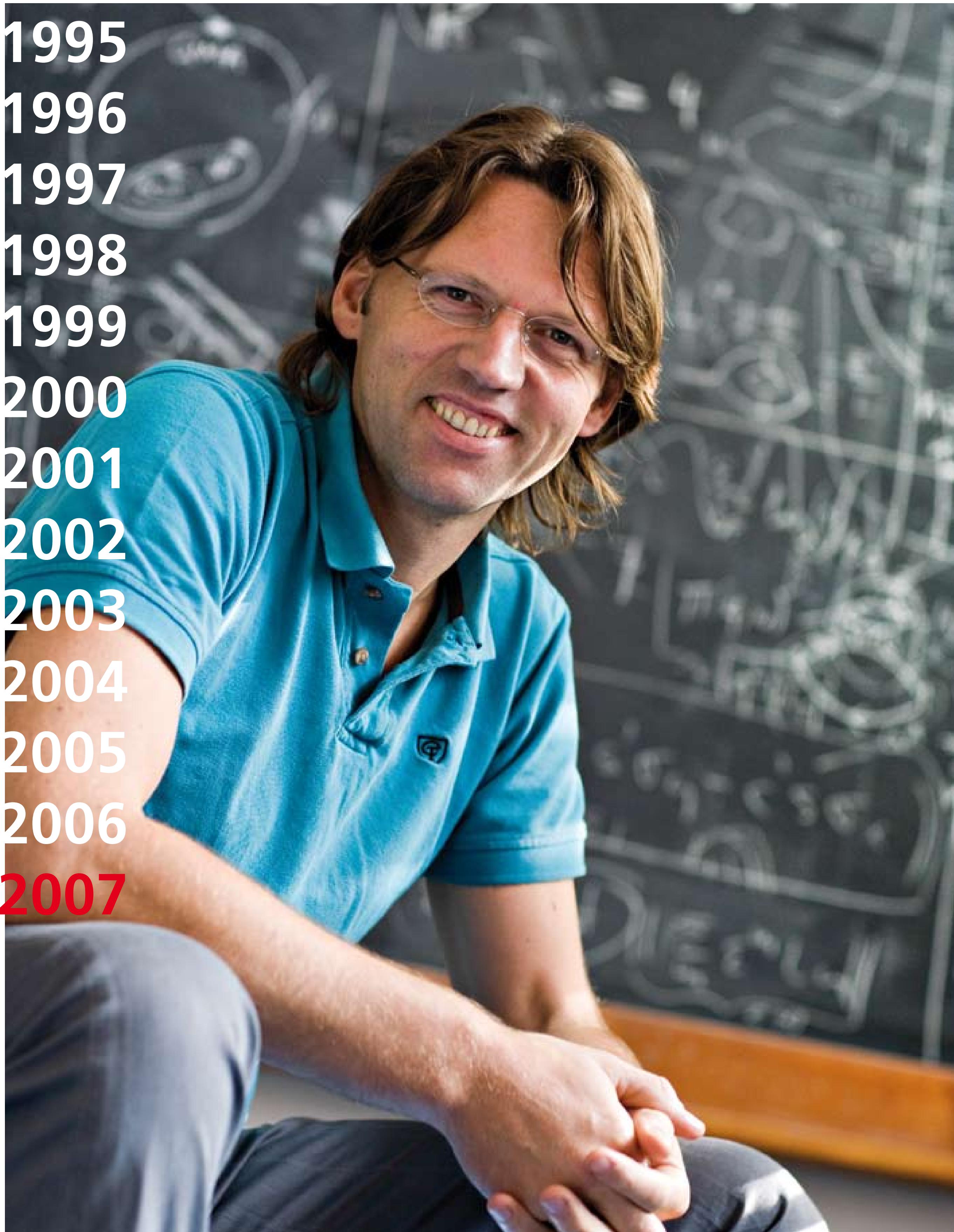
Wind tunnel experiments

Dicke first described the SOS system of plants in the early 1980s. Then, it concerned a predatory mite that was recruited by a plant, to act against herbivorous mites. The recent research into caterpillars and parasitic wasps displayed similar so-called tritrophic interactions – triangular relationships between plants, herbivores and their carnivorous enemies. It demonstrated that the production of the chemical alarm substances was triggered by an enzyme in the caterpillar's saliva. Dicke: 'And all of this takes place right under our noses. When we are outside in nature, we are surrounded by a cacophony of scents, most of which we can only observe with a scent detector.' Together with his colleagues he also discovered that insects have a phenomenal sense of smell. A minimal difference in the broad range of scents secreted from plants is sufficient to make them interesting, or indeed not, for an insect. For example a certain species of minuscule parasitic wasp just 0.5 mm big, can detect the characteristic scent secreted onto female cabbage white butterflies by their male counterpart after copulation. This scent is intended as a warding off signal for other cabbage white males. However, parasitic wasps can use this to track down mated female butterflies. They subsequently hitch a lift with the butterfly female to the place where she lays her eggs. Once there, the parasitic wasp injects her own brood into the fresh butterfly eggs.

Dicke's current research extends beyond just analysing scent trails and the subsequent animal behaviour. He is extrapolating this mechanism to the field of molecular genetics: which genes are activated in a plant when a caterpillar starts to eat it? With this he is building a bridge to a distance discipline. 'Difficult, because they are separate worlds that find it difficult to communicate with each other. Yet, it can potentially yield a lot.' Dicke wants to use part of his NWO/Spinoza Award to investigate, together with molecular biologists, the changes in gene activity cabbage plants undergo in response to insect attack. In this case, the experimental plants will be eaten away not by one but two attackers. It could shed new light on the question as to whether plants that release scents in response to attack by caterpillars are more sensitive to attack by aphids or fungi, for example. Dicke: 'In effect, a plant becomes a different plant the moment it involves other genes in its defence. What are the consequences of this? Can a second attacker subsequently hide behind the defence mechanism against the first attacker?' Research into a small plant – *Arabidopsis thaliana* – has not yet revealed the latter to be the case: an *Arabidopsis thaliana* plant becomes more resistant to attacks from a virus once it has activated its first 'defence genes' against caterpillars. Dicke: 'Very exciting, certainly once we started looking at the level of hormone concentrations and expression of gene activities. We discovered completely new mechanisms that the plant combines.'

Further research must now also show which plants produce the most effective infochemicals to attract enemies of their enemies. This could lead to new forms of crop protection. Dicke: 'With the help of knowledge from fundamental research we can take fifty cucumber lines and develop the one that protects itself the best.'

Marcel Dicke not only participates in research and fundamental science but also writes popular scientific accounts concerning this. Dicke: 'As a scientist, you should also make your work available to a wider public. After all, they have the right to know what we do here with their tax money and just how beautifully the biological world works.'



Prof. L.P. (Leo) Kouwenhoven (1963), Professor of Quantum Transport at Delft University of Technology. Kouwenhovens groundbreaking work on so-called spin qubits is vitally important for the use of quantum information, for example in a fundamentally new type of computer

Making nanoboxes for the quantum computer

The development of a quantum computer – a supercomputer much and much faster than a modern-day PC – is for some scientists the holy grail of modern quantum research. Leo Kouwenhoven contributed to the worldwide search with his groundbreaking research into so-called spin qubits.

'Here we produce very small boxes into which a particle fits that behaves in a quantum mechanical manner', says Kouwenhoven in his room in between laboratories at the Kavli Institute of Nanoscience Delft. 'If you give the box to the right the code 0 and that to the left 1 – the binary code that is the basis for the classical computer – then we are interested in that particle being in both boxes at once. From a quantum mechanics perspective that is possible, as according to the laws of quantum mechanics the particle is there where we find it. Until we actually establish where the particle is, it is everywhere where it could possibly be and that all at once!'

In everyday reality that is utterly inconceivable. However, quantum mechanics has a completely different reality from the world we can observe with our senses. In the classical computer bits are in the state 0 or 1, but the qubits ('quantum bit') in the quantum computer can adopt various compositions of the states 0 and 1: the qubit is found in two states simultaneously. Only on being read is the qubit forced into 'box' 0 or 1. The opening between the two boxes is controlled with an electrical voltage.

Spin

In addition to this, the Delft physicists make use of the typical characteristic of electrons to rotate only left or right on their axis if placed before a magnet. Kouwenhoven's research group was the first in the world to determine the orientation of the 'spin' of an electron. Kouwenhoven: 'You can code both directions in turn as 0 or 1'. The idea now is that a row of such electron spins in a magnetic field can be used for a quantum computer. When the spins are linked and simultaneously superimposed (composite state – 'simultaneously rotating left and right') then in simple terms, 'spin qubits' are created. Since these are considered capable of carrying out processes simultaneously, as opposed to step-by-step in the case of classical computers, just a limited number of spin qubits could provide unprecedented computational power. Code cracking, calculations and database searches could be performed at an amazing speed.

Entwining the spin qubits and bringing them into a composite state still takes a considerable amount of effort. 'The complexity rapidly increases as you produce more qubits and that is what is so frustrating ', says Kouwenhoven. 'Yet on the other hand, understanding this complexity is the biggest challenge of the science. Seen from this perspective I am in the right place: we are busy discovering an exciting new – fundamental – physics.' Meanwhile, his research group has made considerable progress with the manipulation of individual electrons. They have also succeeded in demonstrating the states of superconducting small currents that simultaneously rotate left and right.

Blackboard

Kouwenhoven's fascination for the world of quantum mechanics started when he was a student at Delft. During this period he carried out research into electrical phenomena at a quantum level in the research group of professor Hans Mooij. It yielded a tremendous discovery: all materials have the same resistance at the nano level. 'What's more, that proved to be a universal phenomenon', says Kouwenhoven. 'The article that we wrote about this is the most cited publication from Delft University of Technology'. At that time he came into contact with the Leiden theoretical physicist and Spinoza Award winner Carlo Beenakker, with whom he would later work on many publications. Some of these would prove crucial for the new discipline of nano-electronics. A blackboard in his office full of complex formulas gives a good impression as to what the men exchange ideas about. 'Here we try to translate the formulas into actual implementations. The experiment is our trick', says Kouwenhoven. In the laboratories and clean rooms, which are packed full of self-developed electronics, he experiments, for example, with semiconductors and superconductors. That frequently happens at extremely low temperatures, as atoms close to absolute zero do not move and so the electrons are easier to follow.

Are we about to witness the dawn of the quantum computer? Kouwenhoven laughs: 'Not yet, we are still working at a very primitive level. But I hope that it will work before I retire and that we will make an important contribution to it. I think there is a realistic chance of success.'

Prof. J.W.M. (Wil) Roebroeks (1955), Professor of Palaeolithic Archaeology at Leiden University.

Roebroeks has made original observations on early hominids and the development of human society.

‘An extra bird was just a snack for a Neanderthal’

Neanderthals had significantly higher energy requirements than modern humans. Was that partly the reason for their extinction? Archaeologist Wil Roebroeks will devote part of his NWO/Spinoza Award to unravelling that mystery.

In a deserted brown coal pit in Neumark, Germany – where Roebroeks is currently carrying out an excavation with his students – thousands of bones from large mammals and thousands of stone tools have been exposed. It may once have been a kind of open-air restaurant for Neanderthals. From the crushed bones, with evidence of removed bone marrow, it can be seen that humans were at work here. Early Europeans probably caught their prey animals while these were drinking in one of the many lakes in the then densely forested area. Thanks to brown coal excavations in the former DDR, 100,000 to 200,000-year-old sites are now marvellously accessible for archaeologists. ‘Here in the field we can test the hypothesis that during warm periods, Neanderthals mainly hunted very large animals such as rhinos’, says Roebroeks enthusiastically. The focus on large mammals was probably due to their considerable energy requirements. Neanderthals were large, with well-developed muscles and large brains. Furthermore, they moved around on relatively short legs. Their need to eat larger quantities of different food than modern hunter-gatherers is therefore hardly surprising. An extra bird was a mere snack for them.’

Some estimate that Neanderthal males had daily energy requirements of about five thousand calories. That is almost twice as much as the average modern human. The majority of their diet consisted of large mammals. Given their energy requirements, Neandertals moved camp often, they were constantly on the move with major implications for their archaeological record.

It is still not clear whether modern humans, who appeared in Europe approximately 35,000 years ago, lived at the same time as Neanderthals. Roebroeks is somewhat sceptical towards recent sensational reports about interbreeding between modern humans and Neanderthals. Yet what is clear, says Roebroeks, is that some modern human groups lived very differently from Neanderthals. For example, the sudden appearance of art is striking. They also used other toolkits and hunted a wider range of prey. Studies of the composition of their bones indicate a more varied menu, which may have led to higher birth rates. Roebroeks: ‘With the advent of such a competitor the demise of the Neanderthal could have been a rapid affair. At first glance the differences are small. However, demographic models indicate that the Neanderthals could have disappeared within a thousand years, if indeed their birth rate was slightly lower than that of modern humans.’

Out of Africa

The detective work into the archaeology of Neanderthals is right up the street of the Leiden professor of Palaeolithic Archaeology (2,600,000-10,000 years ago). Roebroeks: ‘The challenge is to use small-scale studies to collect data relevant to the study of the long term development of early human societies.’ With this approach he has slowly but surely brought into focus the contours of early hominids. For example, in the 1980s he caught the eye with publications about Neandertal stone tools. He was less concerned about their shape but more about the material they were made from. How far was that material moved from its source? ‘I wanted

to map how far hominids moved around with their tools', says Roebroeks. 'That research revealed that the action radius of hominids gradually became larger over the course of two-and-a-half million years.'

In 2005, Roebroeks and his British colleague Robin Dennell courted international attention for a critical analysis of *Out of Africa* – the hypothesis that all of our early ancestors up until 1.8 million years ago originated from Africa. The main premise of their argument was that quite simply, too little research had been done outside of Africa to continue selling this hypothesis as an established fact. For example, in the past decade very early skeletal remains of hominids have also been found in China and Georgia. 'The 1.8 million year old finds from the Georgian archaeological site at Dmanisi, reveal that you did not need a large brain or body to leave Africa, as the classical *Out of Africa* hypothesis states. That scenario desperately needs revising. On the basis of skeletal material from just a few worldwide locations and their dating, far-reaching conclusions were drawn about how hominids had spread throughout the world and about their behaviour. That looks too easy to us', says Roebroeks.

His current research concerns the archaeology of Neanderthals, our evolutionary cousins, who are so similar to us – including a large brain – yet from an archaeological perspective also so different from modern humans. Although early *Homo sapiens* shows a quick succession of new technical discoveries – projectile technology for example – archaeologists observe that over hundreds of thousands of years until their bitter end, Neanderthals held on to their tried and tested, extremely simple stone tools and wooden spears. Roebroeks: 'The simplest explanation is that Neanderthals did not change their technology because under the conditions and circumstances in which they lived, these were very effective at meeting their requirements. This is perhaps in some ways comparable to what archaeologists observed for hunter-gatherers who lived on Tasmania until the end of the nineteenth century. Thanks to the NWO/Spinoza Award we can easily set up a comparative study with our Australian colleagues. Fantastic!'

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