# A country of colourful variety

Samples of excellent academic research in the Netherlands





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### Preface

This book offers a selection of outstanding academic research. Grouped into 21 thematic research areas, the collection of case studies highlights the leading edge work of research groups and programmes across the breadth of universities in the Netherlands. It is a work in progress – ongoing research that builds on the solid foundations laid over the preceding decades, which the universities are maintaining and developing further.

There are good reasons for the support of world class research. This is the best way for modern societies to progress and compete in the global economic markets. The Netherlands should be at the forefront of these developments. It is in everyone's best interest. The universities train the scientists and researchers of the future. Leading research paves the way for inspiring, excellent education and provides indispensable incentives for societal and economic innovation. The research undertaken at Dutch universities is directly relevant to society. Dutch research is of exceptionally high quality, as the rankings confirm. International measures of the impact of research publications reveal that Dutch research ranks third world-wide. Researchers at Dutch universities tie with the Swiss for second place as the world's most productive scholars, surpassed only by researchers in the United States. The World University Rankings published by the Times Higher Education (THE) magazine, which assesses both research results and international reputation, lists eleven Dutch universities in the Top 200 academic institutions in the world.

Research is always in motion. In recent years, there has been an increasing convergence and concentration in those fields in which the Netherlands excels. This overview of examples of current research demonstrates this trend. Dutch scientists maintain a reliable and extensive network of international relationships. Scholars and universities work in close cooperation. Visits of researchers from overseas are a clear sign of the strength of research in the Netherlands.

As the familiar warning in the fine print of financial institutions attests: 'past performance is no guarantee of future results'. The same holds true of the snapshot this book presents. The superlative research currently being performed traces its roots back to investments in people and facilities made years ago. We would like to maintain that standard in the future. Achieving that goal will require renewed investment in people and facilities – and they need to be comparable to the investments being made by our international competitors. We are far from confident that this is the case. Time after time, the Netherlands has been shown to lag behind the leading countries in Europe. If we seriously want to fulfil our ambitions, this development is taking us in the wrong direction. The figures at the back of this book show plainly where we stand internationally in terms of quality and in terms of investments. The work done by thousands of Dutch scientists proves that the invested funds are being spent wisely. The Dutch universities are the ecosystem for research talent. Close ties between research and education provide new generations the opportunities they deserve.

Finally, I would like to draw your attention to an extraordinary aspect of research in the Netherlands. The 14 universities are individual institutions and are distinguished by their own achievements. This leads to healthy competition. At the same time – and this is unique in the world today – they work together in close cooperation, as evidenced by the many inter-university institutes presented in this book. It is precisely that combination of cooperation and competition that gives the Dutch scientific landscape its wonderfully colourful variety.

#### Dr Sijbolt J. Noorda

President of the Association of Universities in the Netherlands (VSNU)

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An electroencephalogram (EEG) is used to measure brain activity during language processing.

## The mysteries of communication

The technological developments in recent years have dramatically changed the way people communicate, both with each other and with machines. We not only have the ability to communicate with everything and everyone, but are required to do so. Globalisation compels us to pursue constant consultation and cooperation. Research centres in Nijmegen, Amsterdam and Leiden are taking on the rapidly changing field of language and linguistic research, directing their efforts towards a common goal: discovering how our capacity for communication works and develops.

Dutch research in this field focuses on a number of areas, including the history of language, language diversity, cognition, and how information is processed: how is our written and spoken language constructed? What role does language play in how we learn? How are messages conveyed from sender to recipient? These questions are addressed with determination and gusto and approached from various disciplines. The scope of research is not limited to human language, but also encompasses symbolism, music, and communication with machines and electronic devices.

#### **BABYLONIAN CONFUSION**

Three Dutch research centres each cover their own territory in the research domain. The Centre for Language Studies (CLS) at Radboud University in Nijmegen concentrates on language and cognition, infrastructure, and language and diversity. The fact that the accession of new European Union (EU) Member States and the increasing influx of immigrants have not led to confusion of Babylonian proportions, yields all sorts of avenues for researching language and communication.

The project *Traces of Language Contact*, for which Pieter Muysken was awarded an Advanced Grant of the European Research Council (ERC), brings together a number of highly promising lines of research from the Nijmegen CLS. CLS researchers use research

## Of the nearly 4,000 languages that have not yet been recorded, 50 to 90% will disappear over the course of this century.

results from the field of bilingualism and language contact to gain fresh insight into the nature of linguistic change: do languages change on their own or as a result of contact with other languages? The ERC project headed by Pieter Muysken is looking for answers to this question in the indigenous languages of South America, the many languages spoken in Surinam, languages spoken by immigrants in the Netherlands, and the individual language production of bilingual speakers.

In addition to language, a significant part of communication consists of gestures and facial expressions. CLS has a large research group that studies these aspects of communication at both the national and European level.

#### **ENDANGERED LANGUAGES**

The Leiden University Centre for Linguistics (LUCL) records and researches the countless languages spoken all over the world. Over two-thirds of the 6,000 languages that exist have not been recorded yet, while 50 to 90% of these languages are expected to die out during the course of the 21<sup>st</sup> century. As a result, the opportunity to gain an understanding of the different ways in which languages function will shrink quickly. The research being done at LUCL is vital to make a record of rapidly disappearing knowledge.

#### MAN AND MACHINE

At the Institute for Logic, Language and Computation (ILLC, University of Amsterdam), scholars from various fields – mathematics, linguistics, computer science and philosophy –

examine information transfer as an abstract concept, as well as information transfer between people. The key question is how information coding, transfer and comprehension take place. ILLC research focuses on developing mathematical theories and designing computational models that describe and simulate these different flows of information. Logic and – surprisingly enough – game theory have proven excellent tools for describing the processes.

In the last few years, the fields of neuroscience and logic have been converging. Logic offers high-level descriptions of cognitive functions, yielding new insights and questions, which in turn lead to new experiments at the neural level.



Malinese sign language (LaSiMa) is one of the many languages facing extinction. Leiden based linguist Victoria Nyst is creating a database.

#### Logical reasoning

Logic can offer a powerful tool for studying abnormal behaviour in the area of language processing. The collaborative partnership of Michiel van Lambalgen (ILLC) and Peter Hagoort (Donders Institute for Brain, Cognition and Behaviour) is researching the comparatively rigid reasoning patterns of autistics and the neurological origins behind the thought processes involved.

#### AWARDS AND HONOURS

NWO Spinoza Prize
1996 Professor Johan van Benthem
1997 Professor Frits Kortlandt
1998 Professor Pieter Muysken

• KNAW Academy Professor 2007 Professor Pieter Muysken

• *ERC Advanced Grant* 2008 Professor Pieter Muysken

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences Radboud University Nijmegen



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Setting up and calibrating an eye tracker, a computeraided camera that registers pupil movements.

## Journey of discovery in the cranium

According to forecasts from the World Health Organisation, addressing neurological diseases and disorders will become the top medical priority in the 21<sup>st</sup> century. This field encompasses researching and treating neurological disorders such as Alzheimer's disease, aphasia, ADHD (Attention-deficit/ hyperactivity disorder), schizophrenia and Parkinson's disease. The rapid progress made in brain research in recent years is due in part to cooperation between cognitive science and biomedical neuroscience. A multidisciplinary approach is one of the defining characteristics of the Dutch contribution in this field.



One end of the spectrum is the rapid expansion of interdisciplinary fields of cognitive science, the other is biomedical neuroscience. Dutch research flourishes where these fields intersect. In Amsterdam, Nijmegen, Maastricht, Utrecht and Leiden, scholars from many fields – psychology, neurobiology, medicine, linguistics, logic, philosophy, sociology, physics and computer science – are working towards a common goal: a better understanding of how healthy brains work and develop and of brain disease and imbalances in emotional regulation. The research also includes potential therapies. Close cooperation with university medical centres and commercial enterprises ensures that the results of fundamental research will be applied in the form of the treatment of diseases and disorders.

#### **RESEARCH THAT SERVES THE PATIENT**

In Leiden, the Leiden Institute for Brain and Cognition (LIBC), which is a collaborative association involving about 25 research groups, and the Leiden Centre for Translational Neuroscience (LCTN) focus on cognitive and biomedical neuroscience. The approach taken in Leiden explores the aspects of normal and affected brains, cognition and emotion at various stages of brain development. Innovative methods of brain analysis have been developed. Thanks to the combination of clinical experience and technological know-how, it has been possible to help specific patient groups, such as patients who have difficulty with speech production and language comprehension. Applications have also been found in parenting, education, clinical and ambulatory patient care, medicine, drug development, prevention and policy.

#### **ABUNDANT HARVEST**

In Utrecht, 270 researchers have pooled their resources in five institutes affiliated with Utrecht University and the University Medical Centre (UMC) Utrecht teaching hospital: Helmholtz Institute, Rudolf Magnus Institute, Utrecht Institute of Linguistics (OTS), Research School for Biomedical Image Sciences and Institute of Veterinary Research. Over the past four years, the Brain, Cognition and Behaviour (BCB) initiative resulted in as many as 200 PhD dissertations on the form and function of the brain, on the neurobiological basis for diseases of the brain such as schizophrenia, autism and ALS (Amyotrophic Lateral Sclerosis), and on the genetics of neurological and psychiatric disorders. In the coming years, the researchers will dedicate themselves to fundamental research on how the brain works, with a parallel line of research into the clinical and neurobiological aspects of sick and healthy brains. Their work will rely on advanced imaging techniques and genetic research.

#### **SYNERGY THROUGH COOPERATION**

In Amsterdam, the Spinoza Centre is the collaborative partnership of two universities (VU Amsterdam and University of Amsterdam), two academic hospitals (AMC and VUmc), and the Netherlands Institute for Neuroscience of the Royal Netherlands Academy of Arts and Sciences (KNAW). The recent establishment of the Neuroscience Campus Amsterdam (VUmc/VU) with 450 full time equivalent staff and the Cognition thematic research programme (UvA/AMC) with 140 FTE staff, as well as the establishment of the KNAW's Netherlands Institute for Neuroscience, involving 160 FTE staff, all testify to the focus on the full spectrum of integrative neurosciences, ranging from genetics through neuroimaging to cognitive sciences. Research is being undertaken on development in people of all ages, from children (developmental and educational neuroscience) to adults (twins and patients) and the elderly (gerontology). Collaboration with the academic hospitals provides a stronger research focus on clinical neuroscience. Spearheads of the programme include neurological disorders (MS (Multiple sclerosis) with cognitive aspects), degenerative brain abnormalities (Alzheimer's disease, Parkinson's disease and dementia), neuropsychiatric disorders (OCD

(Obsessive-compulsive disorder), anxiety, depression, stress and addictive behaviours), and the cognitive neuroarchitecture of perception, attention and memory.

#### WHAT DOES THE BRAIN LOOK LIKE?

Examining the brain in action is the speciality of Radboud University Nijmegen's Donders Institute for Brain, Cognition and Behaviour. The institute uses state-of-the-art neuroimaging facilities on the campus in its research. Operating on the principle of encompassing the entire range from molecule to man, the Donders Institute seeks to comprehend the brain and cognition from the genetic/molecular level through to behaviour. The research done here focuses on language and communication, perception and motion, learning, memory and plasticity, and neural networks. The research being done at the Nijmegen-based Max Planck Institute for Psycholinguistics is also integrated into the Donders Institute. In 2007, the 250 researchers at the three centres wrote over 750 research papers. Researchers at Maastricht University's Brain Imaging Centre (M-BIC) are working to improve the research methodology and data processing for fMRI (magnetic resonance angiography?) scans. Part of their efforts include the further development of the Brain Voyager package, now used in over 2,000 research centres all over the world. In collaboration with the Forschungszentrum Jülich (Jülich Research Centre) in Germany, a European centre of excellence is being developed for ultra-high field fMRI (9.4 Tesla) for human cognition studies. Application-based research is also being done on the relationship between stress, depression and degenerative brain diseases like Alzheimer's. Another spearhead in this field of research is the treatment of psychological abnormalities and forensic science, demonstrated, for example, by the Maastricht Forensic Institute, which was launched in 2008.

Professor Peter Hagoort, director of the Centre for Cognitive Neuroimaging in Nijmegen, says: 'Although the brain works like an orchestra without a conductor, the different parts successfully make the right contribution at the right time. We don't yet understand how that's possible, but we're working hard to find out more about it.'

Applied science: the website of Maastricht University's Brain Imaging Centre (http://mbic.unimaas.nl/kinderen/) shows children exactly what happens when an MRI scan is made of a child.

#### Contacts all over the world

The multidisciplinary approach leads to many surprising national and international connections. More than 600 Dutch researchers take part in many projects in the European Framework Programme and work closely with companies such as Philips and Siemens. The research groups are also part of a network of university partners, including the Karolinska Institute (Stockholm), Kyoto University, University of Oxford, Harvard University, K.U. Leuven, the Max Planck Institute (Leipzig), University College London and the California Institute of Technology. Under the auspices of the Netherlands Organisation for Scientific Research (NWO), the national initiative on brain and cognition will guarantee the continuity of these cooperative efforts.

#### WARDS AND HONOURS

- NWO Spinoza Prize
- 2001 Professor Dorret Boomsma
- 2004 Professor Rien van IJzendoorn
- 2005 Professor Peter Hagoort
- 2006 Professor Jozien Bensing
- 2007 Professor Marjo van der Knaap
- *KNAW Academy Professor* 2006 Professor Paul Emmelkamp
- *ERC Advanced Grant*2007 Professor Victor Lamme
  2007 Professor Dorret Boomsma

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences



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Maastricht University Press Office (043) 388 52 22 pers@maastrichtuniversity.pl

Under the auspices of NeLLL, research is being undertaken on developing multimedia environments that support lifelong learning.

## Stepping stone to the knowledge economy

Europe's economic success in the world depends largely on developing knowledge. That statement is set out in the Lisbon Convention, signed in 2007 by the EU Member States. Going to university and then finding a job is not enough. If Europe wants to continue playing a role in the global economy, employees will have to continue developing throughout their lives. The Open Universiteit Nederland is researching the best ways to achieve that ambitious goal.

The traditional education system in the Netherlands is in jeopardy of rapidly becoming outmoded by the demands placed on us by fast-paced societal developments. Many jobs require increasingly complex competencies. Knowledge and skills quickly become outdated due to technological and organisational innovations.

The Open Universiteit Nederland founded the Netherlands Laboratory for Lifelong Learning (NeLLL) to research what the rapidly growing group of 'lifelong learners' needs in order to keep up with the changes in technology and organisational structures and how they can continue to contribute to the development of new knowledge.

The NeLLL is devoted to developing theories, concepts, models and instruments that facilitate employees' ability to update their knowledge and skills, as well as proactively train those in danger of losing their link to the knowledge economy.

Transforming the Netherlands into a knowledge-based society will require many more people to bring their competencies up to standard and maintain them. Now more than ever, people of all ages need the flexibility to decide for themselves how and when they learn.

#### **LEARNING NETWORKS**

Under the auspices of NeLLL, research is being undertaken on developing multimedia environments that support lifelong learning. Theoretical research is combined with solutions for practical application. One example is research being done on ways to promote the formation of flexible and open online learning communities, which make it more appealing to restart or continue the learning process.

The work of the Centre for Learning Sciences and Technologies (Celstec), one of the NeLLL partners, has made a significant contribution to establishing learning standards. The Learning Design standard that Celstec developed was introduced internationally as early as 2001. The standard provides a uniform format for Open Educational Resources, creating possibilities for the free exchange of learning materials. In turn, that facilitates the emergence of open learning networks.

#### A SECOND WAY

Transforming the Netherlands into a knowledge-based society will require many more people to bring their competencies up to standard and maintain them. More than ever before, there is a need for a second way to achieve that goal: a way that is open to people of all ages, who decide for themselves how and when they learn. In 2006, the Open Universiteit Nederland was the first in the Netherlands to launch an experimental project on Open Educational Resources, building a bridge between informal and formal learning. Self-study materials developed by the university have been published on the Internet, making them accessible to the public.



#### Popular model used world-wide

A model developed originally by Professor Jeroen van Merriënboer, the four-component instructional design (4C/ID) system facilitates the design of training and education programmes for lifelong learning. The four components in the model are learning tasks, support information, 'just in time' information and part-task practice. Now used all over the world, the model continues to grow in popularity due to its emphasis on self-directed skill acquisition, which makes it ideally suited to lifelong learning.

#### Recognition in the US

American magazine Training designated Professor Jeroen van Merriënboer 'World Leader in Educational Technology' for the ground-breaking research that he headed. In 2009, Professor Paul Kirschner was named an American Educational Research <u>Association (AERA)</u> Fellow.



OpenUniversiteitNederland

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Religion is a powerful presence in modern Dutch society – politically, socially and culturally – and is thus an essential part of the public domain.

1 1

## Business and law, growth, happiness and faith

One more year of life – how much is that allowed to cost? What are the legal limits within which businesses can operate? How can we comprehend the dynamics of inequality in the world? Why does religion continue to play such a major role in modern society? Society is the research domain of a broad palette of scientists, most of whom conduct interdisciplinary explorations in search of an understanding of the fundamental forces that shape modern society.

#### **RELIGION MORE IMPORTANT THAN EVER**

Religion is back in society. Was it ever gone? In the early 20<sup>th</sup> century, sociologist Max Weber expected that it would vanish. In actuality, new religious groups arise at every turn, the influence of Islam has become a key topic of social debate, and many people who once turned their backs on the church are seeking new forms of religious experience and spirituality. Religion is a powerful presence in modern Dutch society – politically, socially and culturally – and is thus an essential part of the public domain. Recently established, the VU Institute for the Study of Religion, Culture and Society (VISOR) brings together theologians, anthropologists, historians and philosophers to research religion's public role. For example, theologians are studying the role played by religious and philosophical traditions in the private and public domain. What liberties can religious groups attain, and which can they not? VISOR is one of the world's biggest scientific institutes in the field of religion.

#### **CROSS-BORDER CORPORATE LAW**

Any company that operates outside the borders of its home country encounters the laws that prevail in other countries. A firm grasp of those laws is crucial to such companies. Twelve law firms and financial institutions, some of which have international operations, as well as Dutch multinationals joined forces with Radboud University to establish the Business and Law Research Centre (OO&R) as a means of addressing these very issues. OO&R conducts fundamental research in the field of corporate law and analyses national and international developments in legislation and case law. Cooperation between academic



One recent breakthrough was the insight that the position of women in society is a key to understanding the development process of societies – including in Western Europe.

research and corporate law has resulted in structural cross pollination in both directions. Judges, lawyers, corporate lawyers, banks (including De Nederlandsche Bank), supervisory authorities (including the Netherlands Authority for the Financial Markets, AFM) and the legislature have drawn inspiration from OO&R research. Examples include such topical issues as curbing market abuses and regulating financial supervision. Moreover, OO&R is involved in drafting and implementing new legislation in its areas of expertise, including insolvency law. The centre also operates internationally, involved, for instance, in efforts to harmonise legislation in the EU and in projects for the UN Commission on International Trade Law (UNCITRAL).

#### HAPPINESS AND RISK IN AN ECONOMIC MODEL

The concept of 'quality of life' – happiness – plays a key role in health economics. But how do you quantify happiness? Classical economic theories offer less than ideal tools for that purpose. In 2002, psychologists introduced the Nobel Prize-winning field of *prospect theory*, in which happiness and risks can be weighed against each other. Before the theory can be put into practice, many evaluation methods need to be adapted and redeveloped, for example in the area of health. The contribution of the Tinbergen Institute (TI) was the *trade-off technique*. In brief, the technique separates the values of good decisions from the values resulting from coincidence, allowing for more effective assessment of decisions and of happiness. The trade-off technique has had significant impact in the fields of economics, health economics and psychology. Health economics is only one of the fields in which TI works. Three Dutch universities (Erasmus University Rotterdam, University of Amsterdam and VU University Amsterdam) have concentrated their best economic research in this institute. TI researchers have proven themselves to be among the best in the world in various fields, including health economics, development economics, econometrics, labour economics and finance.

#### **COMPREHENDING THE DYNAMICS OF INEQUALITY**

Institutions are the rules and guidelines of a society that makes it possible for people to co-exist - from the Constitution to the custom of arranging marriages for children. The question is the extent to which such institutions play a role in the prosperity, safety, justice, personal development and – ultimately – happiness experienced by individuals. Economists believe that the success of countries, regions and companies depends largely on the prevailing institutions. Determining factors include, for instance, whether there is a constitutional state, whether the people who make decisions are held accountable, whether individuals are free to determine their own actions, and whether there is a situation of mutual trust. Utrecht University's focus area Origins and Impact of Institutions researches the role that institutions play in economic development. The ultimate goal is to comprehend the dynamics of inequality on a global scale and to fathom how they can be changed. It is unique in its interdisciplinary approach to major research themes from the fields of social sciences, law, economics and management: cooperation, inequality, citizenship and markets. These themes are high on the social agenda. The historical dimension is a characteristic feature of the research. One recent breakthrough was the insight that the position of women in society is a key to understanding the development process of societies – including in Western Europe.

#### In the tradition of Jan Tinbergen

'Econometrics is one of the outstanding strengths of the Netherlands' academic scene, and with 26 Fellows, the Tinbergen Institute has one of the largest groups in the world, if not the largest. Many Dutch econometricians are well known internationally [...] and have made important contributions in the tradition of Jan Tinbergen himself. [...] The teaching and research sides seem well interlinked [...]. The students appear to be able to reach an impressively high technical level in econometrics.'

Source: International Peer Review Committee report (2005).



#### Awards and honours

#### • NWO Spinoza Prize

- 1996 Professor Peter Nijkamp
- 2003 Professor Jan Luiten van Zanden
- 2007 Professor Deirdre Curtin

• ERC Advanced Grant 2008 Professor Marco van Leeuwen

NWO = The Netherlands Organisation for Scientific Research



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What motivates employees to delay their pension for a bit?

# Smart strategies for anticipating the grey wave

Europe faces an enormous challenge in the coming decades: finding ways to deal with the consequences of its aging population. How will it impact on the tenability of pension systems? How can affordable healthcare be maintained? Where will the job market find sufficient employees? The Netherlands holds a prominent position in terms of knowledge acquisition and the search for smart solutions to complex issues related to the aging population. Tilburg University is the base of operations for a science network on the topic of life course planning, pensions and aging: Netspar. The network is a successful example

of a public-private partnership in the service sector.

To say Netspar is to evoke the name Lans Bovenberg. The authoritative Tilburg-based economics professor used the money from his Spinoza Prize to launch the Network for Studies on Pensions, Aging and Retirement. With great alacrity, he was able to encourage public and private institutions to participate in his science network: other universities, various government ministries, pension providers, banks and insurers. The strong concept underlying the network ties scientific research to innovative applications. The Dutch Ministry of Economic Affairs acknowledged the crucial role played by Netspar, designating the network a 'Societal Top Institute', in recognition that it combines excellent scientific research with active involvement in the key issues facing society.

#### **BEHAVIOUR AND POLICY AT THE MICRO AND MACRO LEVEL**

What motivates employees to delay retirement a bit? Which elements of the successful Dutch pension system could be used in other countries? What is the relationship between a person's level of income and their health and life expectancy? What factors determine why consumers choose specific financial products? Netspar analyses societal developments and searches for innovative solutions to socioeconomic problems. It researches macro-economic issues, as well as micro-level aspects, such as the behaviour of individual people or households on

Netspar studies show a wide range of diversity in the sense of well-being among Europeans aged 50 and over. Older Dutch and Scandinavian people are much better off in this respect than their Polish, Czech and Southern European counterparts.

the job market and the financial services market. This micro-level research in particular has yielded a wealth of unique data, which also has international appeal. Much of the research is interdisciplinary in nature: economists work with psychologists, lawyers, sociologists and epidemiologists.

#### **THINK-TANK AND FACTORY**

Bringing together academics and practitioners is what Netspar aims to achieve. The network tries out new formulae in which science and practical application learn from each other and exchange knowledge and expertise. Netspar brings researchers, policy officials, and employees from pension funds and insurers together in workshops and brainstorming sessions. By doing so, Netspar offers a unique forum for discussions about policy strategies for the longer term, making a significant contribution by increasing mutual trust, promoting open communication and developing shared visions for the future. This is vitally important in order to overcome the threats posed by the aging population and to utilise its opportunities.



#### Leading position in Europe

Netspar is in the vanguard of European research on the aging population and pensions. The network's highly international nature reflects its leading position: numerous institutions and research institutes in other countries take part in research projects, and prominent scientists from all over contribute to the workshops and conferences that Netspar organises. International cooperation is intensified by the highly active researcher exchange programme and by the organisation of scientific congresses at the highest level. The Netspar science council is comprised of prominent scientists from Harvard University, Boston University, Wharton School of the University of Pennsylvania, University of Toulouse, University of London and Bocconi University.

#### Awards and honours

• NWO Spinoza Prize

2003 Professor Lans Bovenberg

NWO = The Netherlands Organisation for Scientific Research



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What role does the government play in a specific sector, and what are the roles of other players?

## The responsibilities of market and government

Basic facilities such as public transport, education, healthcare, telephones, energy and water are often the topic of debate. Can supply and pricing be left entirely up to the free market? Or should the government intervene via legislation and regulations to keep everything running smoothly? These questions have both economic and legal aspects. Tilburg University responded to this perceived niche in the market, pooling economic and legal expertise in the Tilburg Law and Economics Centre (TILEC) to study these issues.

The general consensus is that ideally the market and government will complement and reinforce each other. The market functions well when there is sufficient competition and when consumers choose critically from the services and goods on offer. In that case, the quality of supply remains high, prices are low and things are done efficiently. The government creates the right conditions, supervises the situation, and only intervenes if the market functions less than optimally.

#### **THE RIGHT BALANCE**

Things, however, go wrong. What exactly would be the right balance between the public sector (government) and the private sector (market)? When should the government intervene? What are the market's responsibilities and what are the government's responsibilities? How can, for instance, social justice (i.e. everyone has access to basic facilities and everyone's needs are met), safety, certainty and environmental care be ensured? In TILEC, economists and lawyers work together to scrutinise these issues. Established in 2002 and drawing from the university's leading economics and law faculties, the Centre aspires to move to the forefront of this international field of research. The researchers work, for instance, with the Netherlands Authority for the Financial Markets (AFM), the Dutch Healthcare Authority (NZa) and various European research institutes. TILEC is part of two EU research networks: CoPECL and the European Corporate Governance Training Network.



#### **LEARNING KEY LESSONS**

Research at TILEC goes in two directions: institutions, competition and regulations on the one hand, and law and financial markets on the other. The same basic elements are seen in all TILEC studies, whether the sector under review is communication, energy, healthcare or the post. What role does the government play in a specific sector, and what are the roles of other stakeholders? What instruments and organisations do the stakeholders have at their disposal? What are the implications and effects of these instruments and organisations? When does it work, and when is it unsuccessful? What lessons can be learned from research on market forces?

#### COOPERATION

In 2006, TILEC and the Netherlands Authority for the Financial Markets (AFM) initiated the establishment of the AFM-TILEC *Research Network on Financial Market Regulation*. This project is their way of stimulating research on the regulation of financial markets. The credit crisis only increases the urgency of this field of research. TILEC has also been partnering with the Dutch Healthcare Authority since 2008. A research team on economics and healthcare regulation is studying competition in healthcare markets.

'The Dutch have acknowledged two things that many other Europeans find objectionable. The first is that it does not matter who supplies certain services, as long as it is done well. The second is that a certain form of competition can make that more likely.'

Source: The Economist, 2002.

#### Who sorts the post?

In 2011, the monopolies currently held by postal companies in the Netherlands will come to an end. That decision was preceded by a fierce debate on the issue of whether the current holders of monopolies could be required to open their facilities to competitors. For example, would it be permitted for a competing company to have TPG Post sort and deliver its mail? TILEC researched the topic in the Netherlands and throughout Europe, comparing the situation to the case of the telecom sector, which was privatised some time earlier. One of the conclusions was that companies should be stimulated more to invest in their own facilities. TILEC's policy recommendations were adopted by the Dutch government and by the European Commission.



### Tilburg ♦ 🚔 ♦ University

#### FURTHER INFORMATION

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Research in Neumark on the disappearance of the Neanderthal.

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## What is a human?

What is important to us? What perspective did our ancestors have on that question? Do we differ greatly from or do we resemble our ancestors more closely than we think? Philosophers take a scientific approach in considering these questions. The research done by archaeologists on human origins and development also touches on the very essence of our being.

Two new professors appointed at the of Philosophy at the University of Groningen will follow in the footsteps of illustrious predecessors and face the challenging task of retaining Groningen's prominent position in this field. Dr Lodi Nauta was promoted to Professor of Medieval and Renaissance Philosophy, and Dr Martin van Hees became Professor of Ethics and Political Theory.

Nauta is interested in the significant periods of renewal that have occurred in Western thought and culture. His research arises from a fascination with the development of philosophy, particularly in the earlier period through to the Enlightenment. Nauta's work attempts to build bridges between different eras – the Middle Ages, the Renaissance and Early Modern times – by linking disciplines such as literature, philosophy and theology to history.

#### **FREEDOM VERSUS INDEPENDENCE**

The work of the research group headed by Van Hees features an unusual combination of method and subject matter. Van Hees is researching questions that cut to the heart of ethics and political philosophy in ways that are far from customary in this field in the Netherlands, using formal tools drawn from logic, mathematics and economics. His main research interests lie in moral philosophy, in particular issues concerning the foundations of liberalism. The research not only breaks new theoretical ground, but is also highly relevant

#### A dig in Kokerihamna, Spitsbergen.



Professor René Cappers, who works in Groningen and holds an endowed chair at Leiden University, was the first non-Egyptian to study the botanical collection of the Egyptian Museum of Antiquities in Cairo.

to society. Working with colleagues from Amsterdam, Tilburg and Stanford, Van Hees ventures out into the neighbourhoods to study democratic decision-making at the local level.

#### **HUMAN EVOLUTION**

Archaeology at Leiden University has a broad orientation in all senses of the word. It encompasses each of the continents, covers eras ranging from the oldest civilisations through to the post-medieval colonial expansion, and involves collaboration with anthropologists, historians and economists, biologists (DNA analysis) and physicists (isotope research). One focus is the research of Professor Wil Roebroeks, who is studying human evolution from the oldest civilisation to the first settlements to the end of the last Ice Age. Professor Willem Willems is taking part in a project financed by the EU – *Archaeology in Contemporary Europe* – which aims to emphasise archaeology's cultural, scientific and economic significance for modern society and to garner interest among the public at large.

#### WHALERS

The ground covered by the archaeologists in Groningen also extends to highly diverse areas in Europe and Asia. Their interests range from the early Stone Age up to and including the period in which complex cities were built. The Arctic archaeology research of Professor Louwrens Hacquebord is a particular speciality. His interests include 17<sup>th</sup>-century Dutch whaling. His research takes place under the auspices of the University of Groningen's Arctic Centre, which was established in 1970. The centre represents the Netherlands in the International Arctic Science Committee (IASC). His colleague Professor René Cappers is a palaeobotanist: by examining the contents of ancient dump sites and waste heaps near the former Roman port of Berenike on the Red Sea, he identifies what people in that region ate and what trade routes existed at that time. His finds include peppercorns from India.

#### **GEOPOLITICAL INFLUENCE**

The Netherlands has left its traces in the Arctic and Antarctica since the 16<sup>th</sup> century. In those years, Willem Barentsz was among the first people to sail to the North Pole, and Dirck Gerritszoon Pomp was a pioneer at the South Pole. Now, Dutch researchers are involved in scientific explorations in the polar regions. One such project is taking stock of the industrial settlements and research stations on both poles: they played a key geopolitical role, having a dramatic influence on the surrounding nature and are in many cases considered cultural heritage sites. The Willem Barentsz Polar Institute, established in honour of the 4<sup>th</sup> International Polar Year 2007-2008, is the focal point for that research.

#### The paradox of the Neanderthal

Although Neanderthals continued to use tools that remained virtually unchanged for hundreds of thousands of years, they were nonetheless adept at hunting big game, able to survive in a wide range of European environments in the Ice Age – through cold and warm periods. Professor Wil Roebroeks from Leiden University, Professor of Archaeology of the Early Stone Age, aims to invest part of his Spinoza Prize in investigating their disappearance. He is heading a major dig in Neumark 'We find Neanderthal encampments here from about 125,000 years ago. Traces of the former vegetation and bone fragments from Neanderthal hunting activity – it's all very nicely preserved there.' It was previously assumed, not even all that long ago, that Neanderthals were highly primitive, incapable of adapting to their changing climate. The situation was actually much more complex than that, Roebroeks states. His research has unveiled the paradox of the Neanderthals.

#### Awards and honours

• NWO Spinoza Prize

2007 Professor Wil Roebroeks

NWO = The Netherlands Organisation for Scientific Research





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Theoretical physics works to come to grips with the mystery of the beginnings of space and time.

## Building blocks of all matter: elementary and interacting

In their quest to discover the building blocks of all matter, theoretical physicists have revealed the existence of a wide range of elementary particles. The standard model describes and predicts the behaviour of those particles, making it the cornerstone of international theoretical physics. Dutch professors received a Nobel Prize for their improvements to the model. Dutch research also plays a leading role in other areas of theoretical physics, such as quantum matter and soft matter. Concentrating research in the Netherlands Institute for Theoretical Physics (NITP) will enable the Netherlands to maintain its key position in the field.

#### **FUNDAMENTAL LAWS OF PHYSICS GOVERNING THE COSMOS**

Professors Gerard 't Hooft and Martin Veltman received the Nobel Prize for Physics in 1999 for providing a stronger mathematical basis for the standard model of particle physics, which can be used to predict the properties of particles that have not yet been discovered. Not that we now have all the answers: This field of research is overflowing with intriguing mysteries about the origins of mass, the early cosmos, the physics of black holes and dark matter. Major progress has been made on the unification theory, explaining forces, particles and space time using string theory, supersymmetry and quantum gravity. Huge breakthroughs are expected in the international arena in the coming years, in part from the particle experiments being conducted using the Large Hadron Collider in Geneva, Switzerland.

#### **QUANTUM MATTER AND QUANTUM COMPUTERS**

Quantum systems constructed from many miniscule building blocks have a much more powerful information processing capacity than systems currently used in computing technology. Quantum critical and quantum topological forms of matter have been identified in solid-state lattices of cold atoms and electrons in which this quantum information becomes visible at the macroscopic level. Companies like Microsoft and Hewlett-Packard


A new theory of quantum gravity states that if we simply take a large number of minimal building blocks of spacetime (such as the triangles in the illustration) and allowing them to interact according to the basic rules of physics, they will magically self-organise into a macroscopic form that exactly resembles our own universe.

want to utilise this line of inquiry to develop a quantum computer and are investing in that potential by recruiting theoretical physicists. The NITP's concentrated theoretical research programme adds the finishing touch to world-class Dutch experimental research in this field.

#### **COMPLEXITY OF SOFT AND BIOLOGICAL MATTER**

The reductionism traditionally practiced in physics, attempting to break matter down into the fewest possible kinds of particles, falls short in the physics of living processes and soft condensed matter. The exceptional processes and phenomena in this field result from the interaction between many different building blocks. Why do grains of sand clump together firmly? How does self-organisation take place? Why do complex macro-molecules display such highly organised behaviour on a large scale? What are the principles of physics behind molecular motors, or the mechanisms by which genome transcription takes place in the cell nucleus? These questions and more have only come under serious study by theoretical physics in the past two decades. Further development of this field is vital not only to science, but also to our knowledge economy.

#### **THE DUTCH SCHOOL**

Physics research in the Netherlands developed a style of research, known internationally as 'the Dutch School'. In this approach, concepts and descriptions that are developed in one discipline are often successfully applied in other specialised fields of research. As a result of this focus on interdisciplinary application, the Dutch approach has influenced the development of the field of theoretical physics world-wide.



The manner that DNA is packaged in our cell nuclei is highly hierarchical.

#### NITP: the power of three

Three research groups at universities in Amsterdam, Leiden and Utrecht have joined forces in the Netherlands Institute for Theoretical Physics (NITP). They focus on three thematic research areas: theoretical high energy physics, soft condensed matter and quantum matter, and quantum computers. Each institute contributes its own strengths, collectively forming an influential scientific consortium. The NITP partner institutes also work closely with other universities in the Netherlands.

#### Future Nobel Prize winners

Recruiting and training young, talented researchers is essential to the success of NITP. Accordingly, the institutes coordinate their Master's programmes and have established a prestigious scholarship programme for the best Master's students from the Netherlands and abroad. Post-doctoral fellows are brought to the Netherlands on individual grants. A committee of five professors is responsible for proactively identifying and recruiting rising stars of research.

#### Awards and honours

• Nobel Prize

1999 Professor Gerard 't Hooft and Professor Martinus Veltman

• NWO Spinoza Prize

1995 Professor Gerard 't Hooft
 1999 Professor Carlo Beenakker
 2003 Professor Robbert Dijkgraaf

2006 Professor Jan Zaanen

• KNAW Academy Professor 2003 Professor Gerard 't Hooft

• ERC Advanced Grant 2008 Professor Michèl Orrit

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences



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The observatory of the European Organisation for Astronomical Research in the Southern Hemisphere (ESO) on Cerro Paranal in Chile. The picture shows four powerful 8m Very Large Telescopes. 

## The universe: the cradle of life

The cosmos is everything. Many parts of it are older, farther, hotter or colder than conditions on Earth. A galaxy half a billion years old is still in its childhood. By the time we see it, its light has already been travelling for 13 billion years. Questions about the universe – What is time? What is space? Where do stars, planets, the Earth and life itself come from? – are questions about our place in the fabric of reality. Astronomy searches for fundamental answers, constantly pushing technology to its limits.

Questions about the nature and development of the universe appeal to a deep-rooted human need to understand our place in the cosmos. The universe is filled with mystery. About 95% consists of dark matter and dark energy, which leave no detectable traces. Everything we can see now is part of the remaining 5%. The universe is also a unique laboratory in which the laws of nature and the processes of chemistry are examined under conditions many times more extreme than what we can reproduce in laboratories on Earth. Researchers allied in the Netherlands Research School for Astronomy (NOVA) are at the forefront of international research on the mysteries of the universe.

#### THE LIFE CYCLE OF STARS AND GALAXIES

The main focus of research at NOVA is how planets, stars and even entire galaxies, like our Milky Way, were formed, how they come to an end, and how they give birth to black holes and subsequent generations of celestial bodies. There are three main research themes. *Formation and evolution of galaxies: from high redshift to the present*: galaxies are the building blocks of the universe. They are collections of hundreds of billions of stars interspersed with thin clouds of gas and dust. The space between the galaxies is almost entirely devoid of content. Astronomers can now look back to a time when the universe was only 4% of its current age. How did galaxies form? How have they evolved over the cosmic lifetime? What role do dark matter and black holes play in galactic nuclei? *Birth and death of stars: the life-cycle of gas and dust:* stars are the chemical factories of the universe. When stars die, the heavy elements (e.g. carbon and oxygen) produced in nuclear reactions are released. In the most literal sense, we are made of 'star stuff'. Which processes lead to the birth of new stars? What are the differences between our solar system and its planets, like Earth and Jupiter, and the planets orbiting other stars? Do massive stars like the ones we can see in the constellation Orion form in a similar way to sun like stars?

Final stages of stellar evolution: physics of neutron stars and black holes: black holes and neutron stars are formed at the most extreme end of a star's lifetime. It is postulated that matter in a black hole collapses under the sheer force of gravity, causing space and time to rupture. Can we observe and verify the predictions of Einstein's general theory of relativity for the properties of curved space time near these objects? What happens when two dense objects collide? Is this the origin of the most powerful explosions we know – the enigmatic gamma-ray bursts? Could this be the source of the high-energy cosmic radiation that constantly bombards our planet?

#### **A SINGLE NATIONAL RESEARCH INSTITUTE**

NOVA is the partnership of all the astronomy institutes at Dutch universities: Amsterdam, Groningen, Leiden, Nijmegen and Utrecht. NOVA's mission is to carry out fundamental astronomical research and to train young astronomers at the highest international level. Approximately half of the students are international. The young PhD graduates fan out to the best research institutes in the Netherlands and all across the world.

#### **TELESCOPES ON EARTH AND IN SPACE**

Modern astronomy involves observations that cover the entire electromagnetic spectrum, requiring telescopes and instrumentation that no single institute can fund on its own. Telescope projects are therefore organised in an international context. Dutch astronomers have direct access to the most powerful optical and infrared telescopes through the European Organisation for Astronomical Research in the Southern Hemisphere (ESO). The Netherlands was one of the founding nations of the ESO, an organisation which is currently run by former NOVA director Professor Tim de Zeeuw. Radio telescopes, space observatories and instrumentation positioned at strategic locations in other parts of the world is also available for use by the NOVA researchers.

#### **'OUTSTANDING SCIENTISTS'**

'NOVA astronomy is at the highest level internationally. In a rapidly changing field, Dutch research astronomers are admired for frequently introducing pioneering techniques in both observation and theory and for their fundamental contributions to some of the most exciting and important areas of contemporary astronomy [...] Dutch PhDs in Astronomy are in great demand, with both national and foreign research organisations competing for these outstanding, highly qualified research scientists.' Source: report by the International Peer Review Committee (2003).

#### **PUBLIC APPEAL**

One of the things that makes astronomy unique is its broad public appeal. The popularisation of astronomy makes it an excellent tool for promoting general interest in science. Within the Netherlands, NOVA's popular website (www.astronomie.nl) offers news and information about its activities. Many visitors make use of the website's 'ask the experts' option. In addition, schools and other organisations can order free promotional and educational materials online.

#### Developing the instrumentation of the future

Fundamental astronomy requires highly sensitive instrumentation incorporated into the biggest telescopes. An important part of the NOVA programme therefore consists of technical research and development on the next generation of instruments, as well as construction and testing of new astronomical instruments, in collaboration with the ASTRON and SRON institutes of the Netherlands Organisation for Scientific Research (NWO), which also play a key role in Dutch astronomy research. The new techniques used here eventually trickle down to commercial applications, such as security equipment and cameras for medical and consumer use. Astronomy promotes technological development due to the extremely high standards of precision it demands from the equipment used in telescopes on the ground and in satellite systems. Delivering the extreme calculating capacity required for astronomy also stretches the ICT industry to its limits.

#### • NWO Spinoza Prize

- 1995 Professor Ed van den Heuvel 2000 Professor Ewine van Dishoeck
- 2004 Professor Michel van der Klis
- KNAW Academy Professor 2003 Professor George Miley
- ERC Advanced Grant 2008 Professor Heino Falcke 2008 Professor Marijn Franx 2008 Professor Conny Aerts

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences



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# Sustainable quality of life on Earth

Time is running out for the world we live in. Ecosystems are in danger of becoming permanently disrupted, fossil fuels are becoming increasingly scarce, and the use of those fuels is causing dramatic changes in our climate. Energy conservation, restricted CO<sub>2</sub> emissions and improved sources of renewable energy are sorely needed. What can be done, what options are feasible, and what consequences do the various choices have? Most of the technical research in this field is done at the three universities of technology in the Netherlands. The focus in Utrecht, Amsterdam and Wageningen is primarily on climate, ecology and the physical environment.

#### **TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT**

Access to energy and natural resources is one of the biggest problems and challenges currently facing mankind. Fundamental breakthroughs are needed in the field of renewable energy systems (solar power, wind, second-generation biomass, nuclear power, energy storage), transition technology and infrastructure. Dutch research has ties to the best research taking place in the world in numerous fields, providing crucial impetus to technological development. The availability of the only academic source of nuclear radiation in Northwest Europe is an important asset in this context. The Biotechnology Department at Delft University of Technology is developing new technologies for the production of renewable fuels, chemicals and products for the pharmaceutical, chemical and food industries. Its unique strength lies in the integration of molecular and physiological knowledge with bioprocess technology. The nanochemical technology research taking place in the Nanochemical Engineering Department is important for solar cells and renewable materials.

#### **THE EARTH AND SUSTAINABILITY**

Sustainability goes beyond technology: research also includes climate, ecosystems, water and socioeconomics. The Institute for Environmental Studies (IVM) at VU University Amsterdam is studying how societal and economic developments harm the environment, and how policy, behaviour and market forces can lead to sustainable solutions. Are new technologies accompanied by new pollution? What costs and benefits will they entail, and how do we deal with them? What are the best strategies for dealing with an environmental problem: reduced pollution or adaptation? The IVM seeks answers to these types of

questions. Water management and water quality have become even more important world-wide as climate changes and population growth have caused water shortages or increased the risk of major disasters. As a multidisciplinary institute, the IVM works on integrated analyses of important environmental problems – climate change, biodiversity and exotic chemical pollution, such as flame retardants.

In Utrecht, research in this field has been combined in the Centre for Earth and Sustainability. At the centre, a total of 1,200 researchers from Utrecht University, Netherlands Organisation for Applied Scientific Research (TNO), Deltares and the National Institute for Public Health and the Environment (RIVM) work together on a broad spectrum of questions from applied science to the very heart of fundamental science. Climate, energy and how we use the Earth are examined from every angle, from feasibility studies on new energy systems and nanotechnology applications to an understanding of the consequences that climate change has on the Earth and its ecosystems. Utrecht is a key region offering extensive expertise on sustainability in Europe, due in part to the presence of the Royal Netherlands Meteorological Institute (KNMI) and many companies operating in the field. The coalition of knowledge institutes and companies is working on major breakthroughs in understanding and forecasting climate change, alleviating the impact of climate change, for example, through CO<sub>2</sub> storage, implementing more effective spatial planning in response to rising sea levels, and protecting coastal and river regions if global temperatures continue to rise.

#### SUPPORT STRUCTURE FOR LIFE ON EARTH

Researchers at Wageningen University are working on the green and blue environment, the support structure for life on Earth. The subjects of research are soil, freshwater and salt

water, air and atmosphere, species and ecosystems. The research activities of Wageningen University can be classified into four thematic areas. The first is the biological, chemical and physical principles of the green and blue environment. The second is the design and functional aspects of landscapes, river basins and coastal zones. The third thematic research area is the development and management of rural and urban areas at national and international level. Finally, the fourth is research on the administrative and socioeconomic aspects of managing the green and blue environment. For example, research by Professor Frank Berendse on grass encroachment on heathland due to nitrogen deposition helped to shape Dutch and European environmental policy. Critical nitrogen standards were formulated and nature management policies for the Dutch heathland have changed: sheep graze the heathlands again and turf is cut regularly.

#### **TIPPING POINT FOR THE CLIMATE**

Nature regularly presents mankind with unexpected, drastic surprises – forests and lakes suddenly transformed into Saharan conditions and coral reefs overgrown with brown seaweed from one year to the next. Lakes in the Netherlands suddenly went cloudy. Professor Marten Scheffer in Wageningen discovered that the change was caused by gradual overfertilisation, causing excessive nutrients to leach into the water. The transformation to cloudy water was sudden and difficult to reverse: a tipping point had been reached. Complex systems like coral reefs, human population centres and climate also have tipping points. Scheffer is now working with ecologists, social scientists and climatologists on this topic. 'The fundamental principles of tipping points are always the same. That makes it possible for use to detect warning signals.'

The IVM works closely with all the important environmental research institutes in Europe and many outside Europe and also conducts contract research for such organisations as the World Bank, the UN, the private sector and non-profit organisations, such as the World Wildlife Fund (WWF).

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#### Working together towards renewable energy

The three universities of technology in the Netherlands in Delft (TUD), Eindhoven (TU/e) and Twente (UT) have joined forces in the 3TU.Centre for Sustainable Energy Technologies. The centre has 750 scientists led by 80 professors, making it one of the most powerful university coalitions in Europe in the field of renewable energy. 3TU initiates various large-scale coalitions, such as Advanced Dutch Energy Materials (ADEM), in cooperation with the Energy research Center of the Netherlands (ECN), which combines cutting-edge materials research with applications for energy systems, building a robust research facility for breakthroughs in the field of materials. In a European context, the 3TU partners are working with the European Institute for Innovation and Technology in the new, ambitious Knowledge and Innovation Community for sustainable energy (EIT-KIC Energy). A final example of cooperation and exchange is the Netherlands Research Platform for Sustainable Energy Supply (NODE).

#### Awards and honours

• Nobel Prize

2007 Nobel Peace Prize for IPCC authors. seven of whom hold a position at IVM: Professor Frans Berkhout, Professor Joyeeta Gupta, Professor Richard Tol, Professor Pier Vellinga, Laurens Bouwer, Heleen De Coninck and Dr Xander Olsthoorn

- NWO Spinoza Prize
- 1997 Professor Rutger van Santen
- 2001 Professor Hans Oerlemans
- 2004 Professor Jaap Sinnighe Damsté
- 2006 Professor Ben Scheres
- KNAW Academy Professor
- 2004 Professor Rutger van Santen
- 2005 Professor Henk Lekkerkerker
- ERC Advanced Grant 2008 Professor Jaap Sinnighe Damsté
- 2008 Professor Ben Scheres

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences







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Because we are becoming more and more dependent on ICT, there is an increasing need for reliable research on the dependability of the systems that safeguard the underpinnings of society.

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# ICT as a basic necessity of life

Security, transport, interactive media, domotics, power supply, logistics, corporate information systems, production – no aspect of society can be imagined without ICT (Information and communication technology) playing some sort of role. The massive scientific interest in the technology that supports the very fabric of our society comes as no surprise. Both fundamental and technical ICT research is done in the Netherlands, as well as research on applications in all conceivable fields.



ICT has drastically changed our society and our economy. Everything, including work, manufacturing and communication, is ICT-driven. While our dependence on ICT grows, so the complexity of hardware, software and communication technologies increases, as well as becoming more 'invisibile', embedded in complex processes and systems. There is intense scientific interest in this field of research, which has such an important influence on our society. Extensive fundamental, technical and applied research is being done in the Netherlands. The size of the Netherlands Institute for Research on ICT (NIRICT) reflects the scope and significance of the field. The institute is a partnership between the three technical universities in the Netherlands (Delft, Eindhoven and Twente) and brings together over 1,200 scientists working in over 70 research groups on a range of disciplines, including computer science, electrical engineering, mathematics and various ICT application domains.

Because we are becoming more and more dependent on ICT, there is an increasing need for reliable research on the dependability of the systems that safeguard the underpinnings of society: the automated payment systems, transport and traffic, and utilities (gas, water and electricity). The Centre for Dependable ICT Systems (CEDICT, a part of NIRICT) focuses on the development and application of methods and technologies that produce dependable ICT components and systems.

# The NIRICT is the most important university research partner in the Netherlands, with 1200 employees and an annual budget of € 77 million.

#### AT THE TECHNICAL END

The COBRA interuniversity research institute in Eindhoven, another 3TU joint effort, conducts fundamental and applied research. COBRA covers the entire range of nano-optics and nano electronics, right down to their application in communication devices and systems. The researchers are involved in materials research on topics such as composite semiconductors, optical polymers, optical active lenses, metallic and magnetic films and multilayers, semiconductor surfaces and metals or oxides, and electrons and phonons in low-dimensional semiconductor systems and other material systems. The results of such fundamental research forms the foundation of, for example, the development of new opto-electronic instruments, electronic components for high-frequency applications, fast packet switching and components for information storage and processing, and information storage using optical, radio or magnetic techniques. Ground-breaking research is being done at COBRA on nano- and microphotonic components and fibreglass communication systems. The final line of research includes ultra-high capacity data transport over fibre-optic lines, ultrafast optical switching and routing, broadband connection networks and broadband communication in buildings.

#### HOW DOES THE NETWORKED SOCIETY WORK?

How does the networked world function? That is the question that the Network Institute at VU University Amsterdam seeks to answer. The mission of this recently established research facility is to improve scientific understanding of the technological, economic and social aspects of our current networked society and to promote its development. No approach is left unexplored. The scholars at the institute come from a range of disciplines, including information systems, communication science, ICT, knowledge management, business and management research, marketing and strategy, economics, artificial intelligence, mathematics, and organisation science. Research at the institute is the basis for innovations in smart buildings, sustainable electricity networks, networked business modelling, e-customs and tools for intelligent web search.

#### **INTERNET: NETWORK OF NETWORKS**

The Internet has developed to become the most important communication infrastructure in contemporary society. It has drastically changed how we communicate and find information, but it has also transformed how companies do business and scientists collaborate.

#### Moving towards web intelligence

Researchers at the Network Institute have made a key contribution to new international standards for web intelligence on the World Wide Web. Communication researchers from the field of social science use these standards to analyse the structure and development of the political debate in the Netherlands, for instance, in the latest Dutch parliamentary elections. The results of this interdisciplinary research are very regularly featured in the press and on TV. With 150 researchers from three faculties of VU University Amsterdam The Network Institute uses a unique and interdisciplinary approach for The Netherlands and abroad. ICT research at VU University Amsterdam achieves a citation impact score for published research papers of 1.6 (60% above the global average), putting it at the top for this field in Europe.

#### From research to market

In the NIRICT Research Lab, an alliance between research groups in Delft, Eindhoven and Twente, researchers test innovative ideas that may have commercial potential in a laboratory environment before they are launched on the market.

#### Awards and honours

• KNAW Academy Professor 2004 Professor Andy Tanenbaum

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A topoisomerase IB protein (green) is inhibited by DNA loops being unwound by cancer inhibitor topotecan (red). The DNA polymerase protein (grey), a protein that duplicates DNA, is inhibited by the loops of DNA.

A CONTRACT

M

Post P

## Small, smaller, smallest

Nanotechnology is considered one of the most important technologies of the 21<sup>st</sup> century. This field of research also affects other areas, including water, food, energy and health, making knowledge of nanotechnology hugely relevant to society.

Scientists are fascinated by the question of how the functions of chemicals and materials can be influenced by identifying their structure right down to the level of their smallest composite particles. Nanotechnology intersects with various scientific disciplines, including biology, medical sciences and physics, and has broad applications in industry and other sectors. Two approaches are used in the field of nanotechnology. In the top-down approach, building blocks are scaled down from the macroscopic level to the nanodimensional scale. The alternative is to work up from the smallest natural building block, assembling macrostructures out of atoms and molecules. These two approaches converge through cooperation between experts from different fields.

#### NANONED

Each of the various Dutch research groups benefits greatly from the knowledge shared by the others. Ten research institutes have joined forces in the National Consortium for Nanotechnology Research, known as NanoNed. NanoNed's budget of  $\notin$  235 million goes to nearly 200 different socially, scientifically and economically relevant projects. NanoNed,

## Nanoscientists operate at scales of one millionth of a millimetre. Nano comes from the ancient Greek word 'nanos', which means dwarf.

FOM Foundation for Fundamental Research on Matter, and Technology Foundation STW set out four research themes in the Strategic Research Agenda for Nanotechnology: bionanotechnology, nanomaterials, nanomanufacturing and 'beyond Moore' (see inset). The agenda also defines four application areas in which these themes are relevant: clean water, energy, food and medicine.

#### **FIRST IN EUROPE**

The Faculty of Applied Sciences at the Delft University of Technology houses the Kavli Institute of Nanoscience, the first institute in Europe to receive funding from the prestigious Kavli Foundation. More than 130 scientists from the seven Delft research groups work in the institute and its state-of-the-art cleanroom on nanomanufacturing and other projects. They use such techniques as electron beam lithography to build nanostructures, varying from superconductors to biopolymers. The Kavli Institute of Nanoscience is at the forefront of the global field of quantum computing – an innovative new concept that may eventually replace the current generation of computers. The institute is establishing a Department of Bionanoscience to examine the interface between nanotechnology and biophysics, synthetic biology and cell biology. Bionanoscience will not only achieve breakthroughs in fundamental science, but will also affect our day-to-day lives with applications in healthcare and energy.

#### **Possible breakthrough**

One of the biggest institutes in the world is in the province of Twente – the MESA+ Institute for Nanotechnology. At MESA+, scientists from various disciplines from the Netherlands and abroad collaborate on biotechnology, nanofluidics, nanoelectronics, nanomanufacturing and nanomaterials, and molecular photonics. MESA+ is a key stepping stone for start-ups that use their advanced research facilities and benefit from their knowledge network and international contacts. The work being done at MESA+ includes ground-breaking research on Mott materials. Like metals, these can conduct electricity, but act as superconductors at relatively high temperatures. When different types of Mott materials are brought into contact with each other, the effects may potentially lead to a breakthrough in superconductivity research.

#### HOW FAR CAN WE PUSH CHEMICAL SELF-ASSEMBLY?

In the interaction between theory and experiment, researchers at the Institute for Complex Molecular Systems (ICMS) in Eindhoven are attempting to replicate systems that occur in nature and relate them to mathematical models. The institute was also awarded a grant from the Netherlands Organisation for Scientific Research (NWO) in 2008 for its research on smart multifunctional medicines. The ICMS uses an unorthodox mode of operation: breaking



MESA+ is a major breeding ground for start-ups, which make use of the state-of-the-art research facilities and benefit from its knowledge network.

through the boundaries of different disciplines, it brings together young and senior scientists in joint multidisciplinary research. The aim is to find an answer to this question: *How far can we push chemical self-assembly?* 

#### **PREFERRED PROPERTIES**

Nanotechnology researchers are also trained at the Institute for Molecules and Materials (IMM) at Radboud University Nijmegen, which focuses on the design and study of molecular structures and materials that have preferred properties and predefined functions. The IMM specialises in a 'bottom-up' approach to nanotechnology: molecular assembly, materials research, characterisation and nanoprobing. Cooperation between different fields (especially between chemists, physicists and mathematicians) is a key success factor in this regard, leading to new breakthroughs like the ultrafast manipulation of spins using light and to the formation of spin-off companies. The 20 IMM research groups work on areas ranging from condensed matter nanoscience to chemical and biochemical synthesis. The institute has state-of-the-art experimental facilities, including a High Field Magnet Laboratory, a modern NMR centre, the iNanoLab and a laser laboratory, in which a Free Electron Laser is currently under construction.

#### **INSPIRED BY NATURE**

Molecules, atoms and electrons exhibit behaviour at the nano level that conflicts with what we might intuitively expect, making it difficult to determine how the structure and composition of materials determines the properties of those materials. Despite this fact, this is precisely the aim of the Zernike Institute for Advanced Materials – a leading research school in Groningen. Chemistry, physics and biology are used to explore options for designing, developing and researching new functional materials. This interdisciplinary approach is characteristic of the Zernike Institute and can also be seen in its excellent Master's programme in nanoscience. The work involves close cooperation with the Groningen Biomolecular Sciences and Biotechnology Institute (GBB) and the Groningen. GBB research focuses primarily on proteins: how does their structure influence the way in which they work? What exact function do they serve in the cell? Why do they draw such interest from medical science and biotechnology? Once those questions have been answered, it will be possible to build proteins and micro-organisms for medical applications.

In the CSB, chemical and biochemical building blocks are used to replicate the elements of 'real' cells, which in turn can form cells with a specific, non-natural function. The research is interesting because it clears the path for synthetic production of, for instance, antibiotics, biosensors and biochips, but also systems for controlled drug delivery.

#### FIGHTING OBESITY WITH NANOTECHNOLOGY

Even problems such as obesity and sustainable food production can be tackled using nanotechnology research, as the Wageningen Bionanotechnology Centre for Food & Health Innovations has proven. The centre is working on highly sensitive sensors and diagnostic systems that make it possible to assess food quality, adapt production processes and develop new products, for example, foods that have been tailored specifically for certain patients. Another interesting development is the research on molecules that can form new structures independently. This line of study may lead to the development of cell-like structures that contain medicines, which can move through the body in search of cancer cells.

The 'Beyond Moore' theme marks a revolutionary development in the field of ICT. 'The implementation of new optical, electrical and magnetic phenomena at the nanometric scale and the practice of engineering structures at the atomic and molecular scale will lead to the availability of new applications that have a major socioeconomic impact,' states the Strategic Research Agenda for Nanotechnology. 'This will completely redefine not only the possibilities of the hardware itself, but also the interaction between man and technology, as well as its relevance to society."

Awards and honours

- NWO Spinoza Prize
- 1997 Professor Rutger van Santen
- 2001 Professor Bert Meijer
- 2002 Professor Ad Lagendijk
- 2003 Professor Cees Dekker
- 2004 Professor Ben Feringa
- 2005 Professor Detlef Lohse
- 2007 Professor Leo Kouwenhoven
- 2008 Professor Theo Rasing
- KNAW Academy Professor
- 2003 Professor Roeland Nolte
- 2004 Professor Rutger van Santen
- 2008 Professor Ben Feringa
- ERC Advanced Grant
- 2008 Professor Leo Kouwenhoven
- 2008 Professor Jaap Schouten
- 2008 Professor Albert van den Berg
- 2008 Professor Ben Feringa

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences



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Rabin Centre, Tel Aviv, during construction. Design possibilities are expanding thanks to the growing range of options and increasing reliability of computer hardware and software.

## Dutch architecture conquers the world

Famous names like Rem Koolhaas, Ben van Berkel, Erick van Egeraat and Francine Houben have won world-wide renown for the Netherlands in the field of architecture and design. These disciplines are firmly rooted in the Dutch academic world, for example, at Delft University of Technology. Thanks to research by Professor Mick Eekhout and others, daring designs come within the realm of technical feasibility. Mick Eekhout, Professor of Product Development at the Faculty of Architecture at Delft University of Technology, is an architect, structural engineer and independent designer. His broad orientation, encompassing design as well as R&D on materials and building components, enables him to bridge the gap between design and construction. Under his leadership, the faculty focuses, for instance, on research and development on materials, elements and components in systems for the building industry. The emphasis is on prefabrication and industrialisation, but methodology and process management are also included. Practical application is an important aspect of the research. For example, the research group is working with the composites industry on a wide-ranging study on production techniques suitable for 3D sandwich panels and has researched options for glass construction components and constructive systems.

#### **BLOB ARCHITECTURE**

Design possibilities are expanding thanks to the growing range of options and increasing reliability of computer hardware and software. Buildings are being constructed in the most fanciful shapes. This type of liquid or fluid design, also known as free form or Blob architecture, can only be done using new technologies that have not all been fully fleshed

## In 2003, Eekhout was the first designer since 1856 to become a member of the Royal Netherlands Academy of Arts and Sciences (KNAW).

out. Extensive research is being done on solutions for building materials (Zappi research), building technology for 'free form' architecture, industrial production methods, digital engineering and measurement checks. One example is the PhD research of Karel Vollers (2001), who developed 'Twist & Build' models and techniques that show the feasibility of 'twister' façades. Since then, architects all over the world have been creating twisted buildings, such as the Turning Torso by Santiago Calatrava in Malmö. Blob architecture



Médiathèque in Pau, designed by Zaha Hadid and Patrik Schumacher.

demands highly intensive consultation between the architect, structural engineer, manufacturers and contractors.

Other fields of research that facilitate innovative design include Concept House (industrialised and individualised homes), Future Façades (zero energy façades) and domotics (smart, computer controlled electronics).

#### **3TU SPEARHEAD ON BUILDING RESEARCH**

A great deal of innovative building knowledge is available in the Netherlands. Efforts are being made to pool these resources in the 3TU Spearhead on Building Research, a new research programme for the Dutch building industry, spread across the three universities of technology, which aims to facilitate a new future for the Dutch building sector. There are six faculties in the Netherlands related to building and architecture, employing 80 professors and 200 PhD students.

In his Delft-based company, Octatube International, Mick Eekhout focuses on developing building constructions such as glass façades and lightweight glass roofs, sometimes also using other materials such as cardboard and fibreglass reinforced composite material. Octatube achieved a breakthrough in 2005 with the Yitzhak Rabin Centre in Tel Aviv, which has the world's first free spanning roof shells made of fibreglass reinforced polyester.

#### Cross-border cooperation

The Faculty of Architecture at Delft University of Technology has many partnerships, for example, with the Università Politecnica delle Marche, Ball State University Indianapolis, Loughborough University, Cambridge University, Detmold Universitaet and Universität Kassel. Since 2006, Eekhout has been affiliated with the University of Nottingham as Special Professor of Structural Design.



Turning Torso by Santiago Calatrava, Malmö.

## 

FURTHER INFORMATION Delft University of Technology Science Information Office (015) 278 91 11 info@tudelft.nl

Damaged tissues and organs often fail to recover on their own and cease to function. Regenerative medicine tries to repair these damaged parts of the body and keep them functioning.

# Comprehending and reconstructing cells and organs

The extensive field of Dutch biomedical research explores new directions.

Various research groups are finding applications for new technologies derived in part from physics. Researchers expect major developments and breakthroughs in the treatment for a range of diseases. Initiatives involving five universities attract

national and international attention.

At the Nijmegen Centre for Molecular Life Sciences (NCMLS), researchers at the Faculty of Medical Science and the Faculty of Science at Radboud University Nijmegen are examining processes at the cellular level in an attempt to discover the origins of such diseases as cancer, malaria as well as neuron degenerative diseases. The research focuses on three themes: infection, the immune system and recovery from tissue damage; cell metabolism, membrane transport and intracellular transport; and cell growth and cell differentiation. The NCMLS researchers work closely with clinicians to translate the results of fundamental research into new treatment methods.

The 'Molecule to Man' (M2M) biomedical platform facilitates cooperation by the NCMLS, the Institute for Molecules and Materials and the Donders Institute for Brain, Cognition and Behaviour, as well as clinical departments of the Radboud University Medical Centre and Radboud University Nijmegen. Using imaging techniques, M2M literally brings life into focus, from the smallest nanometric scale to the entire human body. This offers scientists the opportunity to research molecular and biological processes, understand pathologies, and develop better methods of prevention and treatment. Synthetic biology is a new phase in biotechnology in which scientists and engineers work together to redesign or reprogramme biological systems (such as a living cell) for non-natural applications, such as the production of biofuels, plastics or medicines.

#### **SHOULDER PAIN**

The research group headed by Professor French van der Helm at Delft University of Technology – Biomechatronics & Biorobotics – made a highly detailed physical 3D model of the muscles and bones in the shoulder and elbow. The model, which is the most advanced in the world, clearly shows how these complex joints work. It has countless applications in the diagnosis, treatment and prevention of shoulder problems, for example, in making shoulder prostheses or treating fractured shoulders. In the US, the model is used to stimulate shoulder muscles in patients with C5/C6 paraplegia (Case Western University, Cleveland) and in rehabilitation for post-stroke patients (Northwestern University, Chicago). The shoulder model is also used as an example for models of other musculoskeletal systems. Van der Helm's group also works with a number of university medical centres in the Netherlands.

#### **ADAPTIVE TISSUE**

Damaged tissues and organs often fail to recover on their own and cease to function. Although it is still in its early days, regenerative medicine tries to repair these damaged parts of the body and keep them functioning by using natural tissues and cells or applying biomaterials designed to mimic natural materials. This not only involves medical and biological knowledge, but also imaging techniques, materials research, nanotechnology, chemistry, physics, mathematics and computer science.

Researchers from NCMLS, the University of Twente and Eindhoven University of Technology are world leaders in this new field. They work together, also involving university medical centres in their research. The groups in Twente specialise in bone, cartilage and the nervous system, whereas the researchers in Eindhoven focus on the cardiovascular system.

#### **SYNTHETIC BIOLOGY**

Professor Bert Poolman heads the Centre for Synthetic Biology (CSB) at the University of Groningen. In the CSB, molecular biologists, bioinformaticists, chemists, physicists and engineers work together in the field of synthetic biology, redesigning complex biological systems. The researchers are breaking new ground in the field of biotechnology. On the one hand, researchers are developing production systems for medicines, proteins and fine chemicals, which are based on existing micro-organisms, but have been completely rebuilt to facilitate non-natural conversions and processes. On the other hand, they rebuild biological components and assign them a new function. For example, receptor proteins that cells use to bind molecules from outside the cell are converted for use as biosensor chips. Channel proteins, which shunt molecules through the cell membranes and can open and close, are used in new drug delivery methods. The chemicals are packed into liposomes and gradually released at specific locations in the body through built-in channel proteins.



Biomedical research also contributes to the rehabilitation of patients. The in Delft developed model of the human shoulder joint is used in the US for rehabilitation of C5/C6 paraplegia and post-stroke patients. Awards and Honours • *NWO Spinoza Prize* 2004 Professor Ben Feringa 2006 Professor Carl Figdor

KNAW Academy Professor
 2005 Professor Rik Huiskes
 2008 Professor Ben Feringa

• ERC Advanced Grant 2008 Professor Ben Feringa

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences

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# **Deciphering the secrets of life**

How does DNA work? What influence do inherited traits have on the way in which cells develop, grow and die? Unlocking the principles of DNA is what scientists aim to achieve in the study of genomes – one of the spearheads of Dutch scientific research. Its practical value is huge. Knowledge in this field has led to crop improvement and to new ways to fight human and animal disease.

#### **BIG BUSINESS**

The trade in seeds and seedlings is big business in the Netherlands, a veritable gold mine – a kilo of tomato seeds is worth four times as much as a kilo of gold. Exports of seed potatoes, flower bulbs and vegetable seeds total € 2.5 billion on an annual basis. That makes us the world's biggest exporter, representing a quarter of international trade in this sector. The secret to this success is close cooperation between academic research and the business community. Researchers at the universities of Wageningen, Utrecht, Amsterdam, Nijmegen and Groningen collaborated with 13 private companies and two chain organisations to found the Centre for BioSystems Genomics (CBSG). The CBSG centre of excellence focuses primarily on fundamental scientific research on the genomes of the potato, tomato and Arabidopsis (thale cress). Tiny and fast-growing, thale cress was the first plant to have its complete genome mapped.

#### **COWS PRODUCING HEALTHIER MILK**

Besides its work on plants, Wageningen University is also a leading centre of animal genome research, with a particular focus on cattle breeding. According to Professor Johan van Arendonk, the Netherlands is eminently suited to such research, because Dutch cattle

### A kilo of tomato seeds is worth four times as much as a kilo of gold.

breeders and the Dutch dairy sector are among the global leaders in the market. We also have a unique animal registration system and an unparalleled knowledge infrastructure for breeding, dairy products and genetics. One of the research projects specifically looks at improving milk quality. An understanding of the genetic differences in milk composition makes it possible to select cows that produce healthier milk, with lower saturated fatty acids and higher unsaturated fatty acids.

#### **PREDICTING GERIATRIC ILLNESS**

The Netherlands has a significant influence on human genomics and heredity research. Professor Frank Grosveld from Erasmus University Rotterdam/ErasmusMC designed the first reliable method for cloning human DNA cosmids (circular DNA segments). His method is used in laboratories all over the world. Professor Jan Hoeijmakers from EUR/ErasmusMC discovered that a powerful survival response may occur in human cells that causes cellular resources to be redirected from cell growth to maintenance or repair, reducing the chances of cancer and geriatric illness. Triggers for the survival response include DNA damage and restricted calorie intake. This insight helps us to understand how aging works at the molecular level. It can also be used to identify biomarkers: specific proteins that predict susceptibility to geriatric illness.



One of the research projects at Wageningen University is to improve the quality of milk.

#### **UNIQUE COLLECTION OF MICE**

Hoeijmakers' work has also been invaluable to genetic research on humans and other mammals. His research team cloned the first gene responsible for repairing human DNA. He was also involved in cloning various other genes linked to human diseases that cause very young children to contract cancer or progeria (premature aging). His pioneering research is the foundation for the concept of transcription syndromes in human heredity. The laboratory has developed a unique collection of mouse strains that mimic these hereditary human abnormalities in mice; these strains are used in other laboratories all over the world for research on cancer and aging.

#### A BETTER UNDERSTANDING OF CANCER

One of the consequences of the aging population is an increased incidence of cancer, with all the resulting personal, financial and societal consequences it entails. Cancer research in Utrecht aims to gain a better understanding of this complex disease at a biological level and to translate it into clinical applications. Pathologists, radiologists, oncologists, surgeons and clinical researchers work in close collaboration. Researchers in Utrecht are also attempting to decipher the molecular regulation of cellular differentiation, growth and death in normal development and in the presence of disease. The approach combines genomics, oncology and cell biology, researching the biology of stem cells and cancer cells. In doing so, the researchers hope not only to come up with better cancer treatments, but also to find new strategies for repairing tissues and organs that have been severely damaged by chronic disease. Utrecht University invested € 25 million in relevant research facilities, which are also used by other Dutch and European research groups.

#### **CAUSES OF INFERTILITY**

Besides its cancer research, Utrecht University also conducts important fertility research. The emphasis in human fertility is on a better understanding of ovary function and early embryonic development. The Faculty of Veterinary Medicine is working on highly promising methods of stimulating tissue recovery and warding off degenerative disease. Stem cell research is a key element here. Research focuses primarily on articular cartilage restoration and chronic diseases of the liver and kidneys. Researchers figured out the causes of infertility in large household pets and developed new treatment methods. The expectation is that the knowledge and models used in that research will also prove fruitful in treating human fertility issues.

#### **FIRST IN EUROPE**

DNA sequencing technology has improved by leaps and bounds in recent years, making it possible to read billions of base pairs in a single analysis. This breakthrough ushers in an entirely new era in which research, diagnosis and treatment can be tailored to a specific patient, based on the person's complete genetic code. Utrecht University holds a unique position in terms of relevant expertise and technology. For example, the Hubrecht Institute in Utrecht has installed the first Applied Biosystems SOLiD gene sequencer in Europe, facilitating high-speed genetic analysis. UMC Utrecht has a Roche 454 DNA sequencer, capable of highly accurate reads of long sequences. The combined analytical capacity of these two machines offers a huge potential for research, leading to better patient selection for new treatments for a range of diseases.

#### € 500 MILLION FOR THE NETHERLANDS GENOMICS INITIATIVE

The Dutch government took a significant step in 2002 in establishing the Netherlands Genomics Initiative (NGI). This network of universities, research centres, companies and NGOs is intended to ensure that society and the economy benefit from the results achieved through genome analysis in the fields of health, food and agriculture, sustainability and technology. The government has allocated  $\in$  280 million for the 2008-2012 period. This amount is expected to rise as high as  $\in$  500 million due to funding from the private sector and other sources.

#### **STRAWBERRY RAKES IN THE CASH**

Not a complicated high-tech invention, but the Elsanta strawberry is the undisputed success among the patents registered by Wageningen University. Everyone who buys a box of these tasty fruits supports Wageningen genomics research. The university receives € 0.01 for every strawberry plant planted anywhere in the world. In view of the near-monopoly held by the Elsanta strawberry in northwestern Europe, the revenues since 1975 have already brought in more than € 30 million.

#### Genes and aging

Our body is made up of billions of cells, and each and every one has all the hereditary traits of the entire organism encoded in its DNA. Each microscopically tiny cell nucleus contains 1.5 metres of DNA, a long-chain molecule made up of six billion building blocks. About 50,000 of those genetic building blocks are damaged every day by UV radiation, chemical compounds in the air or in food, and 'reactive oxygen species' or free radicals released in the respiratory cycle. This DNA damage can cause cancer or contribute to premature aging. Because we want to live long and healthy lives, we need to try to delay the aging process. DNA can be seen as the blueprint for all life. As such, it plays a key role because it is the only molecule in each cell that cannot simply be replaced. DNA tries to protect itself, because it also contains instructions for self-repairing damage. If DNA damage cannot be repaired, errors start cropping up in crucial instructions, causing uncontrolled cell division which can potentially lead to cancer. DNA damage may also result in the eventual death of the damaged cells, which contributes to the aging process.

#### Awards and honours

#### • NWO Spinoza Prize

- 1995 Professor Frank Grosveld
- 1998 Professor Jan Hoeijmakers
- 2001 Professor Hans Clevers
- 2005 Professor René Bernards
- KNAW Academy Professor
  2008 Professor Frank Grosveld
- ERC Advanced Grant
  2008 Professor Hans Clevers
  2008 Professor Jan Hoeijmakers

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences



#### FURTHER INFORMATION

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Wageningen University and Research Centre

What is the link between nutrition and health, and what effect does nutrition have on physiological processes, energy levels and somatotype (body build)?

# Modern dilemmas of food and health

A nice glass of wine or a fast-food snack: eating and drinking are simultaneously a source of pleasure and a health hazard. Researchers at Wageningen University and Maastricht University are studying the correlation between food and health. The resulting knowledge is reflected in the contents of our supermarket shelves and in the guidelines for healthy living.

From production to distribution and from dinner to its constituent molecules, scientists study food in all its forms and functions. Research centres and the public and private sectors work in close collaboration, for example, in the Top Institute for Food & Nutrition (TIFN). Wageningen University and Maastricht University are key partners in this initiative. TIFN focuses on three key areas: food and health, food structure and function, and bacteriological aspects and food safety. Industry and society can benefit from the new insights produced at TIFN, for example, in dealing with disease, determining guidelines for healthy behaviour, and developing healthy new foods that are particularly delicious.

#### WINE AND CHOCOLATE

Eating fish once or twice a week reduces the risk of a heart attack or stroke. An occasional glass of red wine or a square of dark chocolate are healthy too. The powerful antioxidants (bioflavonoids) they contain lower the risk of cardiovascular disease. Wageningen-based Professor Daan Kromhout was the first to discover these facts, which have gradually become accepted public knowledge. The results can be attributed to pioneering work in the field of healthy food and lifestyle, which also incorporates ethical, psychological, sociological and political aspects.
#### **NATURAL PESTICIDES**

Marcel Dicke, Professor of Entomology in Wageningen, discovered that plants not only secrete toxins to defend themselves against their enemies, but can also produce specific pheromones under duress that attract predatory mites which attack the herbivorous insects. Research on these tritrophic interactions creates options for organic pest control and makes a significant contribution to reducing pesticide use in farming and horticulture.

#### **NUTRIENTS AND EATING HABITS**

What is the link between nutrition and health and what effect does nutrition have on physiological processes, energy levels and somatotype (body build)? A research group in Wageningen has developed methods of measuring food and nutrient intake, as well as the determining factors in human eating habits. Research in industrialised countries focuses on the effects that fatty acids and other nutrients have on metabolic disease, cancer and cardiovascular disease. Focus areas in research in developing countries include malnutrition diseases and a burgeoning epidemic of morbid obesity.

#### **NUTRITION OR MEDICINE?**

Another important target group in nutrition research is patients suffering from acute or chronic disease. The centre of clinical nutrition research is in Maastricht, where scientists are working on an integrated clinical nutrition concept unique in the Netherlands or internationally. Clinical nutrition has experienced fascinating developments in the past decade, including a shift in emphasis from acute to chronic patients, from therapy to prevention, but also blurring lines between nutrition and medicine.

#### **HEALTHY LIFESTYLE**

Researchers in Maastricht work closely with leading clinicians in the academic hospital, focusing on applications in medical practice. The primary research focus is on diseases related to metabolism and specific chronic ailments: what metabolic effects result from the combination of food, exercise and toxicology? The research results can be seen in national and international guidelines for a healthy lifestyle.

#### **EATING AND EXERCISING WITH DIABETES AND COPD**

Maastricht-based research school NUTRIM studies chronic illnesses such as COPD (chronic obstructive pulmonary disease) and diabetes from the perspective of 'integrated care'. This approach, developed by the WHO, does not limit its focus to the disease, but also looks at healthy behaviour and risk factors, particularly in relation to nutrition and exercise. The results show that specific behavioural factors influence the disease, depending on its phase of progression. Research at NUTRIM combines medical technology expertise with an understanding of how the metabolism works.

#### New, SMART PETRI DISH

Professor Willem de Vos attracted world-wide attention with his invention of a new Petri dish. Analysts have been using the classical Petri dish to study biological samples or to culture cells and bacteria for over 200 years. The variant developed in Wageningen contains a microchip with millions of tiny compartments, in which miniscule quantities of bacteria, fungi or cells can be cultured simultaneously. This potentially makes it possible to isolate new species that could not be cultured separately before.

### Fatty foods accelerate post-op recovery

Going in for an operation on an empty stomach? This standard practice may change someday soon. Research by Maastricht-based Professor Wim Buurman revealed that fatty food in the intestines sends the brain a signal to suppress the immune response and prevent unnecessary inflammation. This knowledge may help to improve the healing process after an operation. The risk of post-op infection and complications is relatively high, especially among elderly or chronically ill patients who are less healthy to begin with. Eating a high-fat snack not long before the operation may be a cheap, simple and safe way to reduce the body's autoimmune response and accelerate recovery.

#### Awards and honours

• NWO Spinoza Prize

- 2007 Professor Marcel Dicke
- 2008 Professor Willem de Vos
- *KNAW Academy Professor* 2008 Professor Pierre de Wit

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences



#### **FURTHER INFORMATION**

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Research activities at MOVE concentrate on the nature and significance of human movement for health and well-being.

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# Growing old, staying mobile

The ability to move easily means a good quality of life. As life expectancy goes up, more and more people are facing a loss of mobility. In addition, modern technology has significantly reduced the need to move, with all the negative effects that has on human health. Research on human movement

affects everyone and may reduce healthcare costs.

Researchers from three faculties of VU University Amsterdam have pooled their knowledge, experience and expertise in MOVE. Their objective is to understand human movement in order to optimise mobility for healthy people and for patients. Their research includes both normal and pathological functioning. The research activities are integrated into daily healthcare practice. The focus at MOVE is on prevention and recovery of injuries and disorders of the musculoskeletal system and on tissue and organ recovery.

#### YOUNG, OLD, SICK, HEALTHY

The research institute not only works with patients suffering from the consequences of osteoporosis, arthritis or cerebral haemorrhage. Children and healthy adults are also included in their studies. Conducting research in collaboration with Amsterdam football club Ajax, MOVE is studying children with brain damage and healthy elderly people. A good example of research at MOVE is a project that assesses the walking patterns of children with brain damage using a 3D imaging system. Muscle activity and response intensity are also measured. The data makes it possible to analyse the effect of spasticity during movement. Falling down and breaking a hip: the nightmare of many elderly people. MOVE research concentrates on what happens when an elderly person trips while walking. The aim of the



research is to gain a better understanding of the physiological processes that occur at that time. The results of this research may lead to lower costs of healthcare, emergency care and hospitalisation, as well as potentially reducing overall healthcare costs in the long term.

#### ONLY THE BEST IS GOOD ENOUGH

MOVE was founded in 2008, but its researchers have been working together for years in the Institute for Fundamental and Clinical Human Movement Sciences (IFKB). The IFKB is an alliance between departments of VU University Amsterdam, VU Medical Centre and UMC Radboud (Nijmegen). The IFKB is the only Dutch research school focusing exclusively on the study of human movement. Since its launch in 1995, the research school has consistently received top assessments for quality in every respect from academic reputation to fundraising methods.

### **Results**

- lower costs of healthcare
- emergency care and hospitalisation
- reducing overall healthcare costs in the long term.

#### **BRAINSTORMING FROM ALL ANGLES**

Research activities at MOVE concentrate on the nature and significance of human movement for health and well-being. Examples of research questions include: how does the human body produce movement? What forces are involved in the process? What energy is required for movement? Where does that energy come from? Answers to these questions can only be found through an interdisciplinary approach using input from such diverse research fields as anatomy, molecular biology and psychology and clinical disciplines such as orthopaedics, neurology, physical therapy and geriatrics.

### Ajax football players and VU University Amsterdam: a reliable pair

In June 2008, MOVE announced that it would be expanding its partnership with Ajax. The Faculty of Human Movement Sciences will develop programmes for muscle training and coaching. The programmes will be integrated into the Ajax Football Centre, the football knowledge institute that Ajax plans to establish. This partnership between Ajax and VU University Amsterdam is based on years of history. Ajax and the VU Medical Centre have been working together for years – for instance in treating the players' injuries.



#### FURTHER INFORMATION



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Researchers design and build new bioactive molecules and evaluate the effectiveness and safety of new medicines, new treatments and drug delivery methods.

# What will be in the medicine cupboard in 2020?

The driving force behind the medical revolution since the Second World War has been the discovery of new medicines. Despite intensive drug development research, there is still no treatment available for many life-threatening and chronic illnesses. New medicines require research on the molecular processes behind diseases. Research in this field is taking place at, for example, the universities in Utrecht, Leiden and Groningen, supported by the private and public sector.

Drug research and development are extremely time-consuming. It generally takes ten to twelve years for a new medicine to reach the patient. Pharmacological research also requires a great deal of multidisciplinary work and cooperation by university researchers and researchers in the pharmaceutical industry. This is the only way to discover new opportunities for pharmacological intervention. The work of the Utrecht Institute for Pharmaceutical Sciences (UIPS) and the Leiden/Amsterdam Centre for Drug Research (LACDR) is indispensable for new developments in chemistry, medical science and biology. Together, the two research institutes cover the entire range of university medicine research from drug discovery through to drug utilisation.

#### **FROM DISCOVERY TO DISPENSATION**

The UIPS was founded in 1992 as a research department in Utrecht University's Faculty of Pharmaceutical Sciences and is now part of the Utrecht University Faculty of Science. The UIPS is the core of the Utrecht University focus area on Drug Innovation, in which groups from other research institutes participate. The UIPS has a range of research programmes on the discovery, development and use of medicines. Research is being done on developing more efficient drug delivery methods and on monitoring new medicines to ensure safe use and optimal curative properties.



No new class of antibiotics was discovered between 1962 and 2000. More and more micro-organisms have become resistant to medication. Many chronic illnesses still lack any form of treatment. There is still a lot of work to be done.

The researchers active at the UIPS come from a wide range of disciplines, including molecular science or life sciences, and include medical and veterinary researchers as well. All this makes the Drug Innovation focus area an ideal platform for drug knowledge and a valuable resource for researchers and research partners from universities as well as pharmaceutical and biotech companies.

#### **How does it work?**

The LACDR focuses on innovative drug research and research-related education. The basis of LACDR research is a fundamental understanding of how drugs work. Researchers design and build new bioactive molecules and evaluate the effectiveness and safety of new medicines, new treatments and drug delivery methods. The LACDR and Leiden UMC co-initiated the establishment of the Leiden Centre for Translational Drug Discovery & Development.

#### FROM THE LAB TO THE PATIENT

At the Groningen Research Institute for Asthma and COPD (GRIAC), fundamental research is linked to patient-oriented applied research. Researchers work closely with healthcare professionals to study all the aspects of asthma and chronic obstructive pulmonary disease (COPD). Research findings are adapted directly to clinical practice. The GRIAC researches epidemiological risk factors, genetic backgrounds for allergies, environmental factors, and diseases related to smoking, as well as the influence of treatment methods on the severity and progress of the diseases under study. The institute is also working to develop new methods of assessing diseases and treatment effects without causing new side effects.

#### NATIONAL AND INTERNATIONAL RECOGNITION

- The UIPS and the Drug Innovation focus area are very effectively incorporated into life sciences at Utrecht University. Financial support is provided by the Netherlands Organisation for Scientific Research (NWO), Technology Foundation STW, special programmes, TI Pharma, the EU, and countless companies. The UIPS has also been successful in generating spin-off companies.
- Professor Bert Leufkens is chairman of the Medicines Evaluation Board. He is a member of the EMEA working group on pharmacovigilance and heads the UIPS centre for collaboration with the WHO in Geneva.
- GRIAC and LACDR both have an excellent academic reputation within the Netherlands and abroad, and receive support from NWO, the EU and countless international research organisations. The many partnership projects with the pharmaceutical industry and successful spin-off companies also serve to prove the relevance of their academic work.

Illustrating the support that the private and public sectors give universities, research teams from universities and companies cooperate in the Top Institute for Pharma (TI Pharma). It was founded in 2006 as an initiative of the Netherlands Federation for Innovative Drug Research (FIGON). Ground-breaking research is done in the TI Pharma alliance. The aim of its multidisciplinary approach is to improve efficiency in research and development of new drugs. Several university research centres – UIPS, LACDR and GRIAC – are important partners.

#### Awards and honours

• NWO Spinoza Prize 2000 Professor Dirkje Postma

• KNAW Academy Professor 2004 Professor Ron de Kloet 2007 Professor Dirkje Postma

NWO = The Netherlands Organisation for Scientific Research KNAW = Royal Netherlands Academy of Arts and Sciences







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Despite the use of high-tech equipment and sophisticated laboratory facilities, biomedical research into coronary and coronary artery disease continues to require a human touch.

HA

# A closer look at common causes of death

One in three of us will die of cardiovascular disease. There is no denying the social relevance of this field of research. Every year, the consequences of heart failure, congenital heart defects and vascular conditions such as thrombosis and vasoconstriction affect many thousands of people directly or through a friend or family member. As a result, the diseases are more widely known than the relevant field of research: translational molecular medicine.

The focus of cardiovascular research in the Netherlands includes the origins, prevention and treatment of cardiovascular disease. At Maastricht University, this field is studied in the Cardiovascular Research Institute Maastricht (CARIM), which plays a key international role in cardiovascular research.

#### **EARLY DIAGNOSIS TO PREVENT WORST-CARE SCENARIOS**

The nearly 250 researchers at CARIM work with the Cardiovascular Centre at the Academic Hospital Maastricht (azM) on finding applications for molecular mechanisms in patient care. CARIM research concentrates on the options for diagnosing the development of chronic cardiovascular disease at an early stage, on differentiation between diseases, and on identification and treatment of high risk cardiac patients. Fundamental and clinical studies aim to learn more about thrombosis and haemostasis (the mechanism that stops excessive blood loss). Studies are also conducted on how healthy and failing hearts function and on the vascular biology of blood vessels.

Examples of recent innovation by CARIM include the development of a very early biomarker for cardial ischaemia (reduced blood supply to the heart) in heart protein FABP, the development of a molecular imaging technique for detecting cell death using annexin V, and the application of a new pacing technique to support a failing heart.

#### NATIONAL AND INTERNATIONAL COOPERATION

CARIM takes part in key European research programmes (FP6 and FP7) and in nearly every Dutch platform: Parelsnoer, CTMM, the BioMedical Materials Programme (BMM) and TI Pharma. The Maastricht UMC+ and Maastricht University have jointly invested € 7.3 million to continue developing CARIM as a centre of excellence for research.



#### **HAPPY IN THE WORKPLACE IN LIMBURG**

People living in the province of Limburg are two to three times as likely to have a heart attack as people living in other parts of the Netherlands. This elevated risk could be attributed to the Limburg lifestyle (e.g. residents of this province seem to exercise less than those in the rest of the country). Maastricht-based cardiologist and Professor Leo Hofstra worked with a colleague from the University of California (USA) to develop the Heart Attack Prevention Programme for You (HAPPY) cardio-fitness programme. The cardiologists want to slow the increase in cardiovascular disease by introducing health checks world-wide. The method appears to work. A pilot involving 1,000 people last year showed that risk scores dropped by an average of 15%. Blood pressure also went down significantly among the participants. Apparently, as many as 82% also adopted a healthier lifestyle. Hofstra will be starting his research close to home, among his colleagues at Maastricht UMC+. About 2,500 UMC employees will be taking part - blood samples will be taken and height, weight, waist measurement and blood pressure will be recorded. The data will be expressed as a risk score, which used to generate that person's risk of having a heart attack within ten years. Everyone will receive a personal report on their score accompanied by personalised recommendations and a year of personal coaching. After a year, there will be a second HAPPY Health Check to see if anything has changed. The HAPPY programme will limit its work to Maastricht UMC+, the provincial authority of Limburg and the ABP pension fund have also started using HAPPY in the workplace. In addition to the work in the Netherlands and the United States, India is also taking part in the project. Nearly 8,000 people world-wide are now involved in this very promising research platform to investigate risk factors for developing cardiovascular disease.

#### Tailored technologies

Working with the Faculty of Biomedical Engineering at Eindhoven University of Technology, Philips Medical Systems, Philips Research and Organon, CARIM helped to found the Centre for Translational Molecular Medicine (CTMM). Nearly 100 universities, university medical centres, medical technology suppliers, chemical companies and pharmaceutical companies collaborate in a unique public-private consortium. The centre develops medical technologies that may lead to new 'personalised' treatments for life-threatening diseases and illnesses that threaten the quality of life, treatments tailored to a specific patient. The primary focus of the CTMM research programme is on finding remedies for cardiovascular diseases and cancer - the two leading causes of death in the Western world. In 2008, the CTMM was allocated € 150 million in funding for nine new projects, which funding comes from the Dutch government, universities and various private parties.

#### Awards and honours

KNAW Academy Professor
2004 Professor Maurits Allessi

KNAW = Royal Netherlands Academy of Arts and Sciences

#### **FURTHER INFORMATION**

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Maastricht University

Erasmus MC is also working on a long-term population study among a large cohort of children: Generation R.

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# Fighting disease at the source

In recent decades, a growing number of diseases are reaching epidemic proportions, including morbid obesity, SARS, cardiovascular disease, Bluetongue, Q fever, diabetes, avian influenza and HIV. What causes such epidemics? More importantly, how do we stop them as quickly as possible? In addition to epidemiological research, such a task requires fundamental research on infection

and immunity in humans and animals.



In the Netherlands, three biomedical centres lead the way in this field of research: University Medical Centre Utrecht (UMCU) and the Faculty of Veterinary Medicine in Utrecht, Erasmus University Medical Centre in Rotterdam (EMC) and the Academic Medical Centre in Amsterdam (AMC).

#### **MULTIDISCIPLINARY APPROACH**

The broadest approach is used in Utrecht, where infectious diseases and epidemiology are addressed from a wide range of different disciplines: human and veterinary medicine, pharmaceutical sciences, environmental science, mathematics, statistics, information and computing science, and risk analysis. This multidisciplinary approach ensures the rapid large-scale deployment of research results for application in studies and research programmes at centres working on cardiovascular disease, cancer, infectious diseases, pharmacology, environmental and occupational diseases and psychiatry. A good example of research in Utrecht is a project that has been running for nearly ten years now, researching the link between long-term exposure to air pollution and lung cancer and mortality. It is the first time that the effects of air pollution, traffic intensity and traffic noise on cardiovascular mortality have been researched together. The conclusion (unsurprising, but a cause for concern) was that air pollution leads to earlier mortality. Infectious Diseases & Immunology is one of the focus areas at Utrecht University. Over 200 researchers conduct leading research in such areas as food infections, resistance to antibiotics, vaccine development and immunological disorders (allergies, asthma and arthritis).

The approach used at Utrecht University has an excellent international reputation, as evidenced by the financial support that the research institutes receive from, for example, the Netherlands Organisation for Scientific Research (NWO), the National Institutes of Health, the Netherlands organisation for health research and development (ZonMw), the Dutch government, charitable foundations (from door-to-door fundraising), the EU and the industry.

#### **HOSTILE VIRUSES**

Ground-breaking work on virology is being done in Rotterdam, under the inspiring leadership of Professor Ab Osterhaus. In recent years, the expertise at Erasmus University Rotterdam on such topics as avian influenza, influenza, infectious diseases in populations of wild animals, SARS (Severe Acute Respiratory Syndrome), HIV/AIDS and bioterrorism was made available to the broader public due to his involvement.

Osterhaus heads the Virology department's Influenza Team. Its activities include vaccine development and virus control. One of the more striking recent results to come out of the research group is the development of an effective vaccine for avian influenza. This vaccine protects against new variants of the virus and can therefore be used preventative. A medicine to inoculate against SARS had previously been developed in Rotterdam, catapulting the research group into the world media.

Erasmus MC is also working on a long-term population study among a large cohort of older Rotterdam residents, referred to as ERGO. In the ERGO study, 10,000 men and women aged 55 and older have been tracked since 1999. All sorts of aspects are included in the study: what they eat, how often they exercise, whether they have an active social life. The researchers then see whether patterns can be detected in the presence of those aspects and the occurrence or non occurrence of disease. Scientists hope the study will offer options for predicting, delaying or even preventing the onset of illnesses like dementia, cerebral infarctions and Parkinson's. The study also aims to facilitate identification of the causes of diseases in order to develop better treatment methods. A comparable cohort study, Generation R, is being done on the growth, development and health of children.

#### **HIV AND AUTOIMMUNE DISEASES**

Infection and Immunity is a priority research theme at the Academic Medical Centre of the University of Amsterdam. Research on how the immune system works is relevant to both topics. Fundamental research on processes of cell biology is important for the development of new diagnostic tests and treatment methods. Research at the AMC-UvA covers this entire spectrum.

One characteristic of AMC research is how questions that arise in clinical practice translate into research on functional mechanisms of cell biology, resulting in innovative solutions: translational research. The AMC's ground-breaking research on HIV is a good example of this approach. The Amsterdam-based research focuses on the origins, spread and prevention of HIV and on patient treatment: new treatment methods, drug resistance and side effects of antiviral therapy.

The number of autoimmune diseases and allergies has risen sharply in the Western world over the past few decades. Fortunately, therapies have been developed at an equally rapid pace, thanks in part to research at the AMC-UvA. Moreover, a growing understanding of the immune system also helps reduce organ rejection in transplant patients. Infection and immunity research at the AMC-UvA has a strong international focus. Researchers take part in the FP6 and FP7 EU programmes and 25% of the PhD students and post-doc population is international.

**Epidemiology** is the study of the causes, transmission and control of diseases in human and animal populations.

**Virology** is the study of viruses and their characteristics: what illnesses do they cause? How can they be isolated and cultured? How can they be used in research and therapy? **Immunology** is the study of the immune system – the defence mechanisms triggered in the body in response to pathogens and foreign substances.

### Research tools

The Academic Medical Centre in Amsterdam developed the VIDISCA programme, which allows for the discovery of new viruses in diseases that have unknown causes. An important tool for bacteriological research was also developed: unique animal models that can be used to study pneumonia. Finally, a special mouse strain has been developed with a human immune system, known as the HIS mouse, yielding new insights into how the immune system works.

#### Awards and honours

Heineken Award
2008 Professor Bert Brunekreef

• ERC Advanced Grant 2008 Professor Piet Gros





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Three million of the sixteen million people living in the Netherlands suffer from musculoskeletal problems. Representing nearly one in five of the total population, their numbers are increasing rapidly.

## Prevent rather than cure

The Netherlands can pride itself on its close-knit system of outpatient primary healthcare. It can be attributed in part to medical researchers who work with politicians and social scientists in the Netherlands to build a healthcare system that adapts to meet the developing needs of the population. Various Dutch research institutes do their part in researching the quality of 'neighbourhood healthcare'. Their focus is on prevention.

The Netherlands School of Primary Care Research (CaRE) is a collaboration of four research institutes: the CAPHRI School for Public Health and Primary Care (Maastricht University), the EMGO Institute for Research in Extramural Medicine (VU University Amsterdam), the Centre for Evidence-Based Practice (Radboud University Nijmegen) and the NIVEL Institute for Health Services Research (Utrecht University). Their joint objective is to develop scientific evidence based knowledge on primary health care and implement this knowledge in practice. CaRE aims to maximise research effectiveness by combining relevant fields of research and coordinating joint activities by the participating institutes. CaRE research focuses on outpatient care, primary care and health policy.

#### **DAILY CARE**

Maastricht University is internationally known as a centre of excellence for healthcare innovation. Its CAPHRI research school primarily focuses on improving primary care: the type of healthcare that affects everyone's day-to-day lives. CAPHRI researches the entire process from prevention to aftercare and rehabilitation. The quality of healthcare is viewed from the perspective of patients, professionals and society overall. The development of the Balance Meter effectively illustrates the research that CAPHRI does.

# Of all employees, 5% are responsible for 95% of the costs of illness-related absence in the long term.

While nearly every institute related to healthcare is involved in efforts to help people stop smoking, CAPHRI has taken matters a step further by developing an anti-smoking vaccine. The vaccine prevents nicotine from reaching the brain, thus preventing the release of addictive positive sensation stimulants like dopamine. Recent trials have proven that the NicVax is safe and may stimulate the human immune system to produce antibodies to nicotine.

#### **PERFECT MATCH BETWEEN PATIENT AND CARE**

Many researchers are convinced that evidence-based healthcare is the key to improving primary care. The focus here is healthcare based on the very best scientific information available. Experts in the field work together in the Nijmegen Centre for Evidence Based Practice (NCEBP). Demand for their work has increased since research has shown that there are patients who are unable to receive optimal or even sufficient healthcare, and patients who receive unnecessary care that may even cause harm. The NCEBP takes a multidisciplinary approach in its attempt to find answers to two fundamental questions. The first is what we consider to constitute 'effective, efficient and acceptable healthcare and prevention'. The second question is how quarantees can

be put in place to ensure that every patient receives that care.

In cooperation with experts from such fields as medical science, epidemiology, social science, economics, nursing, medical services and ethics, the NCEBP is able to research disease prevention and efficient treatment for health problems such as cancer, cardiopulmonary disease, mental illness, neurological disorders, infectious disease and fertility problems.

#### PUBLIC CARE, PRIMARY CARE AND LONG-TERM CARE

The EMGO Institute for Health and Care Research at VU University Amsterdam researches chronic illness and aging. Its research is grouped into four thematic areas: diabetes and obesity, mental health, quality of care, and musculoskeletal disorders. Research at EMGO is intended to lead to improvements in public and primary healthcare, rehabilitation and other long-term care.

The societal relevance of the research becomes clear in view of the realisation that overweight and obesity have taken on nearly epidemic proportions in a growing number of communities. One consequence of this development is the growing number of adults and children with Type 2 diabetes. Scientists from EMGO research programmes aim to change the lifestyle of these groups. Depression, anxiety disorders and musculoskeletal disorders are among the most common and most expensive health problems in the Netherlands. A longitudinal study has been running in Amsterdam for over thirty years now, examining the link between physical activity, nutrition and the occurrence of musculoskeletal disorders. The final research domain, long-term care, is increasingly important due to aging: more and more people need long-term care. EMGO researches causes and progression, preventive measures, treatment and effective care for these patient groups.

### Balance Meter: sound predictions cause absenteeism to drop

In cooperation with the health and safety department of ABN AMRO, CAPHRI developed the Balance Meter, a web-based screening device that predicts long-term absence through illness. The figures clearly show that such tools are no frivolous luxury: 5% of employees are responsible for 95% of the costs of illness-related absence in the long term.

A survey among 12,000 employees proves the effectiveness of the Balance Meter. Employees identified as 'very high risk' by the screening tool have an eight to 16 times higher chance of long-term illness-related absence.

Employees who showed an elevated risk of long-term absence based on a prediction by the Balance Meter received guidance from health and safety services at an early stage. Absence through illness ultimately proved to be 35% lower than absenteeism among employees who did not receive such guidance.

#### Awards and honours

• KNAW Academy Professor 2005 Professor Martijn Katan

• ERC Advanced Grant 2008 Professor Dorret Boomsma

KNAW = Royal Netherlands Academy of Arts and Sciences



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# **Appendices**

#### **INTERNATIONAL INDICATORS**

- 1. Overview academic staff and academic publications in 2007
- 2. Trends in citation impact scores
- 3. Publication productivity of countries based on employee efforts
- 4. Public-private partnerships in science
- Percentage of participation and percentage of budget from the Sixth Framework Programme (FP6)
- 6. ERC Starting Grants & Advanced Grants in 2008
- 7. Percentage of researchers in professional population and GERD per capita as a % of GNP
- 8. Ranking Research Intensive Universities



#### **1 OVERVIEW ACADEMIC STAFF AND ACADEMIC PUBLICATIONS IN 2007**

Source: VSNU



Maastricht University

This picture gives us an overview of the number of academic staff (FTE), both teaching and research, and the number of academic publications of the various research universities in 2007. Since 2002, the number of academic staff has increased slightly by 8.6%. Over the same period, both the number of publications and the total number of students (211,000 in 2007) show an increase of 18.4%. The total number of PhD graduates in 2007, nearly 3,200, shows an increase of 26%.

#### **2 TRENDS IN CITATION IMPACT SCORES**

#### Universities in the Netherlands 1993-2006

Source: NOWT Science and Technology Indicators 2008 (CWTS/Thomson Scientific Web of Science. Calculations: CWTS)



#### Country comparison 1993-2006

Source: NOWT Science and Technology Indicators 2008 (CWTS/Thomson Scientific Web of Science. Calculations: CWTS)

	Impact 1993-1996	Impact 2003-2006	Change in impact between 93-96 and 03-06 (%)
Switzerland	1.43	1.41	-1.4
USA	1.44	1.37	-5.2
Netherlands	1.19	1.34	12.1
Denmark	1.13	1.33	17.9
UK	1.19	1.24	3.9
Canada	1.14	1.22	6.8
Norway	0.93	1.22	30.5
Belgium	1.09	1.20	10.5
Sweden	1.10	1.20	8.9
Ireland	0.88	1.17	32.9

The citation impact score is an important gauge of scientific quality because it measures citations by other researchers and indicates peer appreciation of each other's work. The global average is '1'. Dutch scientists are cited more frequently than average and the Netherlands ranks third in the world in terms of citation impact. A significant percentage of the major growth exhibited between 1993 and 2006 comes from the universities. All the universities of the Netherlands are currently performing better than the global average.

#### **3 PUBLICATION PRODUCTIVITY OF COUNTRIES BASED ON EMPLOYEE EFFORTS**

Source: NOWT Science and Technology Indicators 2008 (CWTS/Thomson Scientific Web of Science. Calculations: CWTS)



Researchers in the Netherlands are among the most productive in the world. The number of articles published per researcher (FTE) in the public and semi-public sector ties with Switzerland for second place world-wide. The country's many articles represent 2.6% of the total number of scientific publications in the world.

#### **4 PUBLIC-PRIVATE PARTNERSHIPS IN SCIENCE**

Source: NOWT Science and Technology Indicators 2008 (CWTS/Thomson Scientific Web of Science. Calculations: CWTS)



Public-private research networks play a crucial role in building and maintaining relations between the private sector and knowledge institutes. Such networks bring together knowledge supply and demand. Approximately 8.5% of Dutch scientific articles are co-authored by scientists from universities and companies. This percentage ranks the Netherlands in line with countries that have a comparable scale in the scientific sector. A recent benchmark study showed that Dutch universities make a major contribution here. For example, relatively speaking, Eindhoven University of Technology has the most publicprivate publications world-wide, and Delft University of Technology is ranked in fifth place.

#### 5 PERCENTAGE OF PARTICIPATION AND PERCENTAGE OF BUDGET FROM THE SIXTH FRAMEWORK PROGRAMME (FP6)

Source: European Commission and European Research Council 2008



The Netherlands is a major participant in the European Framework Programmes (FP). In total, the Netherlands contributes about 5% to the budget for the framework programmes. However, more money flows from the EU to the Netherlands than vice versa. In FP6 (2002-2006) a total amount of  $\in$  1.1 billion was allocated to Dutch institutions and enterprises, about 6.6% of the European total. The number of Dutch participations is also relatively high: approximately 5.5%. The trend continued in FP7. In its first year, the Netherlands once again participated extensively. Moreover, it shares first place with Belgium in terms of the highest success rate for research proposals: 22%.

#### 6 ERC STARTING GRANTS & ADVANCED GRANTS IN 2008

*Top 10 countries on the basis of the total number of grants in the initial rounds* Data: European Research Council

	Life Sc	iences	Physic Eng	s &	Social Humai	Sc & nities	Total		%	
	SG	AG	SG	AG	SG	AG	SG	AG	SG	AG
United Kingdom	15	18	26	20	17	12	58	59	19.2%	21.5%
France	15	11	19	14	6	8	40	35	13.2%	12.8%
Germany	9	11	20	9	4	5	33	26	10.9%	9.5%
Italy	8	4	14	11	4	4	26	20	8.6%	7.3%
The Netherlands	6	5	11	9	10	5	27	19	8.9%	6.9%
Switzerland	10	9	5	10	1	3	16	28	5.3%	10.2%
Israel	8	4	14	9	2	0	24	15	7.9%	5.5%
Spain	14	5	6	1	4	5	24	12	7.9%	4.4%
Sweden	4	5	5	9	2	1	11	16	3.6%	5.8%
Finland	3	4	3	2	1	1	7	9	2.3%	3.3%

(SG=starting grant, AG=advanced grant)

The European Research Council awarded the first starting grants (for young researchers) and advanced grants (for senior researchers) in 2007 and 2008. This new European competition, based solely on scientific excellence, is exceptionally selective. Out of 9,000 applications, only 300 starting grants were awarded. Good Dutch performance in this competition testifies to the extensive research talent in the Netherlands. Although the top four countries have many more researchers, the Netherlands and Switzerland are doing very well relative to their size.

#### 7 PERCENTAGE OF RESEARCHERS IN PROFESSIONAL POPULATION AND GERD PER CAPITA AS A % OF GNP

Source: OECD (MSTI 2007-2) and European Union 2008



Research investments are low in the Netherlands. Our country invests about 1.67% of its gross national product in research, about 1% of which comes from companies. That means that the Netherlands has the lowest investment level of the countries that we like to compare ourselves to, performing lower than the European average. Moreover, Dutch investment has remained at the same level, compared to an annual growth of several per cent in other countries. The number of researchers as a percentage of the professional population in the Netherlands is the lowest of the countries in this region: about five researchers per 1,000 people. Scandinavia, Japan and the US have nearly twice as many researchers.

#### **8 RANKING RESEARCH INTENSIVE UNIVERSITIES**

	CWTS Leiden Ranking Green list				ARWU Shanghai		THE	UTD
	World Top 100	World Top 250	European Top 100	European Top 250	World Top 500	European Top 100	World Top 200	Тор 100
UU	47	83	19	29	47	9	67	-
LEI	63	121	27	41	76	23	64	-
VU	48	84	15	25	101-151	35-58	155	-
UVA	50	88	18	28	101-151	35-58	53	-
RUG	-	127	30	45	101-151	35-58	144	-
TUD	-	86	11	17	152-200	59-79	78	-
EUR	-	56	8	13	152-200	59-79	126	61
RU	-	141	40	62	152-200	59-79	-	-
WUR	-	123	29	43	152-200	59-79	142	-
UM	-	133	31	46	303-401	125-168	111	-
UT	-	-	-	23	303-401	125-168	200	-
TU/e	-	-	-	15	402-503	169-210	128	-
UVT	-	-	-	-	-	-	-	52

The international lists of the world's best universities also offer an impression of the quality of teaching and research. The most important are the Leiden Ranking of the Centre for Science and Technology Studies (CWTS), the Academic Ranking of World Universities (ARWU) and the Times Higher Education (THE) ranking. The Leiden ranking is based on the number of citations per articles in the various fields of science, distinguishing between the 100 and 250 top universities in the world and in Europe. The latter ranking also includes smaller universities. The Leiden ranking and the ARWU ranking only look at research achievements. The THE ranking also includes reputation. The UTD Top 100 Worldwide Business School Ranking is based on articles published between 2004 and 2008.

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