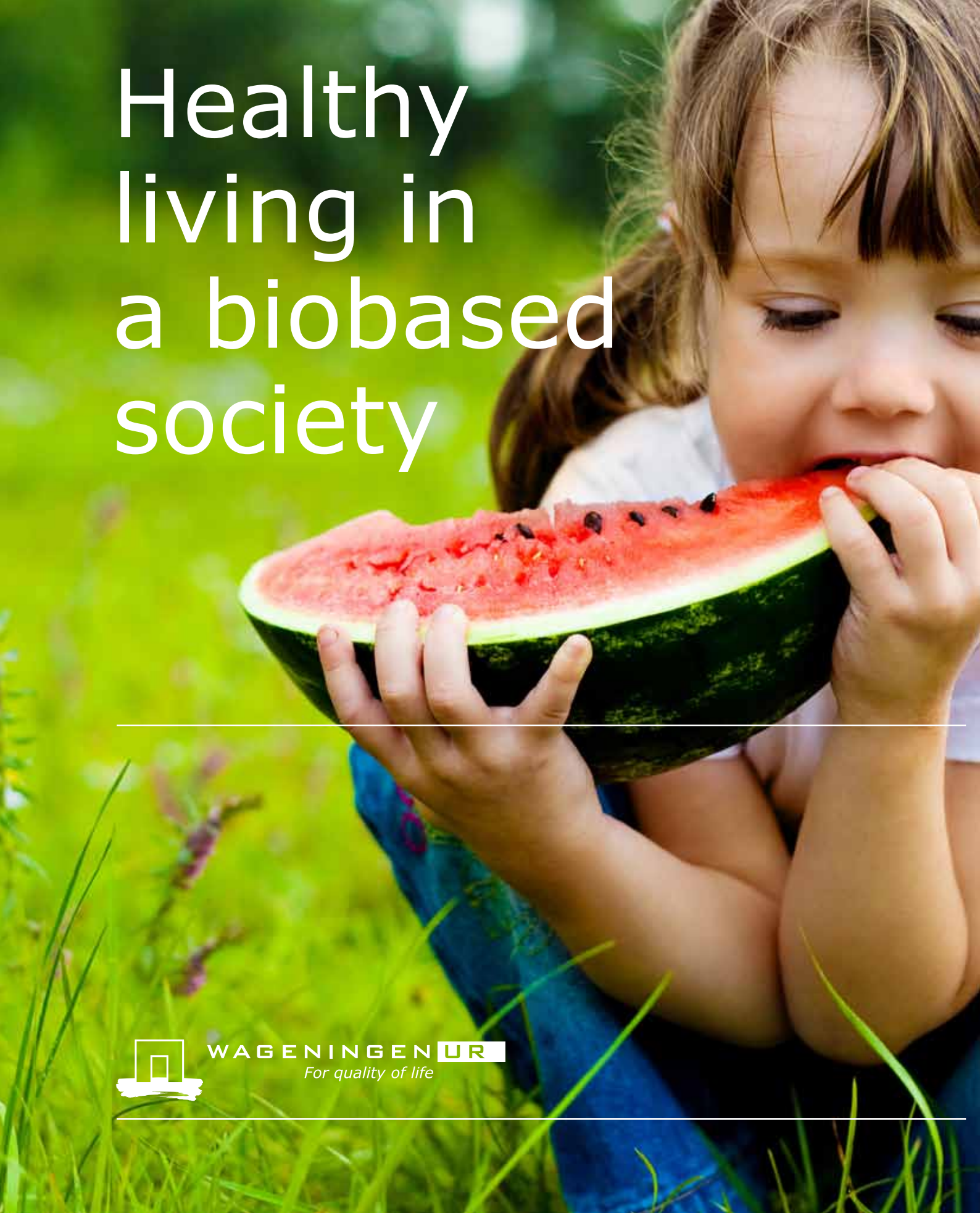
Healthy living in a biobased society



WAGENINGEN UR
For quality of life

Healthy living in a biobased society

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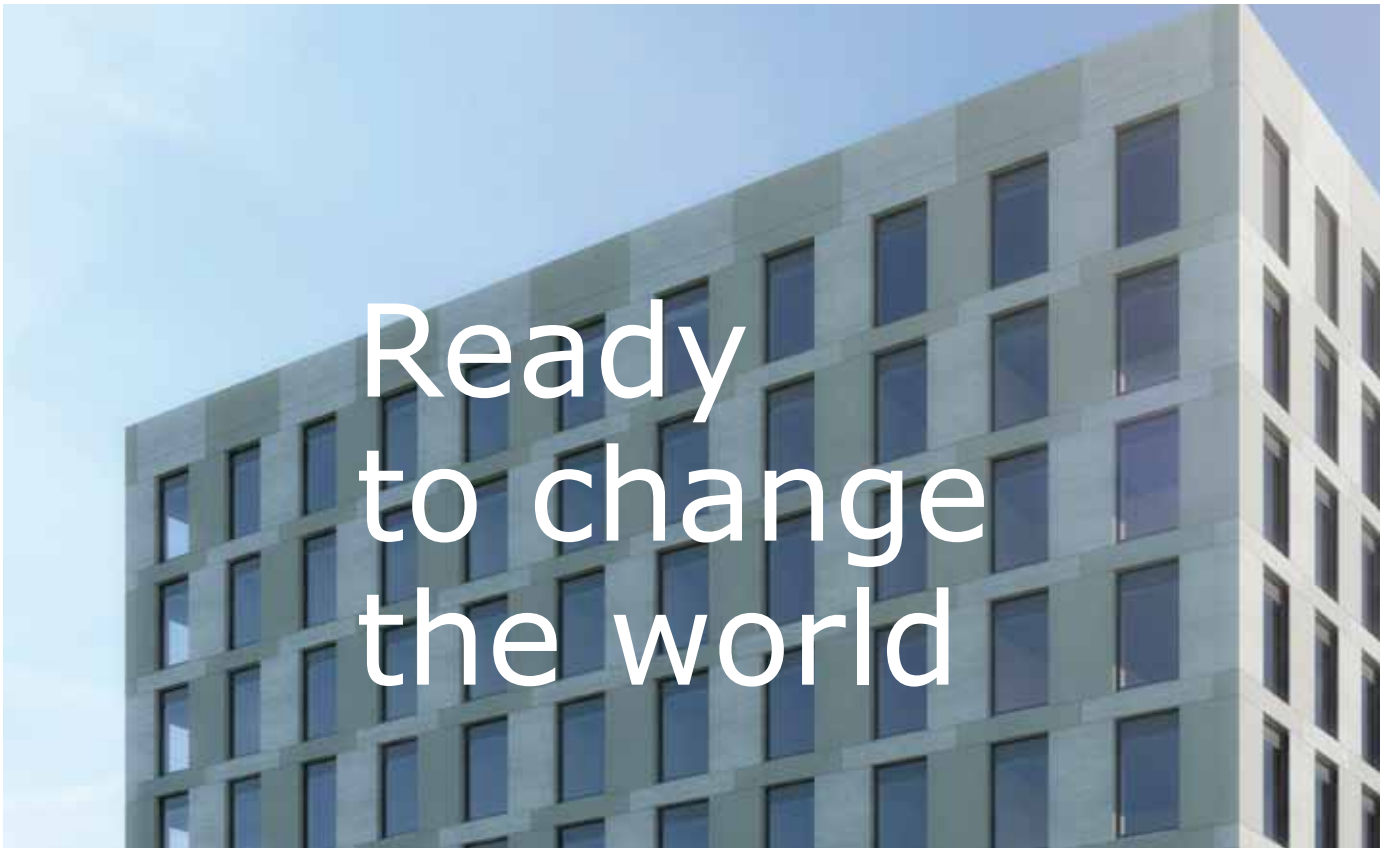

Ready to change the world

This publication covers a wide array of subjects, ranging from physical chemistry to food microbiology, from water technology to food for the elderly. While the subjects may not initially seem related, they all focus on the same question: How can we lead healthy lives in a biobased society?

This vital question unites the underlying disciplines within the Agrotechnology & Food Sciences Group (AFSG) knowledge unit of Wageningen UR (University & Research centre). A good example is the research into the influence of food on health. Our food scientists analyse what transpires in our bodies when fatty acids enter our stomachs, right down to the molecular level. We use these same fatty acids in our research into the production of biodiesel from oil seeds. The two disciplines may seem worlds apart, but in reality the step between them is a small one. And it is this connection that makes AFSG so unique.

Our work revolves around health and food in a biobased society. We develop knowledge, train people, and help governments and industry to apply this knowledge. The strength of AFSG lies in the way we combine fundamental research with its application in practice. At the same time we cherish the open connections we have with other scientific and social disciplines within Wageningen UR and with external partners. Our work has served as the foundation for many successful market introductions, several of which are included in this publication.

Every year the Wageningen campus trains hundreds of students to be professionals in the healthy nutrition and living environment domain. Our student influx is high, and the popularity of our knowledge domain is very welcome at a time when the world is looking for people capable of realising genuine breakthroughs in knowledge and technology.

Together with smaller and larger companies, knowledge institutes and governments, AFSG is ready to increase its impact on the world. Finding solutions for the major challenges that lie ahead is our ultimate ambition and this publication gives you an insight into what we are doing to achieve this goal.

Raoul Bino - *General Director Wageningen UR Agrotechnology & Food Sciences Group*

A conscious choice

The Agrotechnology & Food Sciences Group offers a variety of Bachelor's programmes with follow-up Master's: Agrotechnology, Biotechnology, Food Technology, Molecular Life Sciences and Nutrition & Health. Rolf Marteijn, Programme Director Nutrition & Health: 'These programmes have a varied student population, with students having one thing in common: studying at Wageningen University was a conscious choice. They chose content.'

‘Many students do not realise just what a good reputation Wageningen UR has until they go abroad for an excursion or internship. Most of our students don’t choose Wageningen simply for the university, or its reputation. They choose Wageningen because of the content of the programmes. They may opt for Nutrition & Health because they are interested in preventive health care, for instance. If they wanted to cure people, they would study Medicine. The close link between health and nutrition is obvious, as are the problems associated with poor nutrition. Disease, diet, allergies, the obesity epidemic: nutritional issues are all around us. This is what makes Nutrition & Health one of the top programmes in AFSG.’

Looking round carefully

Nutrition & Health covers every aspect of food and nutrition: choices, consumption, digestion and the effects on health. At three different levels: from population to individual and right down to cell and molecular level. The first year is an introductory year in which students orient themselves. They explore the subject matter more broadly and deeply during the second and third years, spending time at one of Wageningen UR’s partner universities if necessary. ‘You choose a minor for the free choice part of the programme. This takes half an academic year, so students can decide to take a minor at another university here in the Netherlands or even abroad. Again, they look around carefully before making an informed decision. It’s the same with the Master’s: not all students automatically opt for the follow-up Master’s in Nutrition & Health or Food Safety. They choose the subject that interests them most.’

50/50

Future employment only appears to play a minor role. Finding work is not a problem (at the moment): a large percentage of Wageningen UR students find a suitable job within several months. Marteijn: ‘About 50% of our graduates start a career in research. Generating new knowledge. The other half apply their knowledge to socially relevant projects, for example within local health authorities, at the Netherlands Nutrition Centre Foundation or in education. *Science for impact*.’
Marteijn follows graduates’ careers via the LinkedIn alumni group. ‘It’s nice to see who ends up where. They’re all over the world, and most of them are doing well. We have every reason to be proud.’

Wageningen University scores well in the Guide to Universities. Rolf Marteijn: ‘The University has topped the table for several years. This means an awful lot to us because the programmes are evaluated by the students themselves.’ Programmes are accredited every five years; in the most recent round they were assessed as ‘good’ with a particularly strong international orientation.

Rolf Marteijn - *rolf.marteijn@wur.nl*

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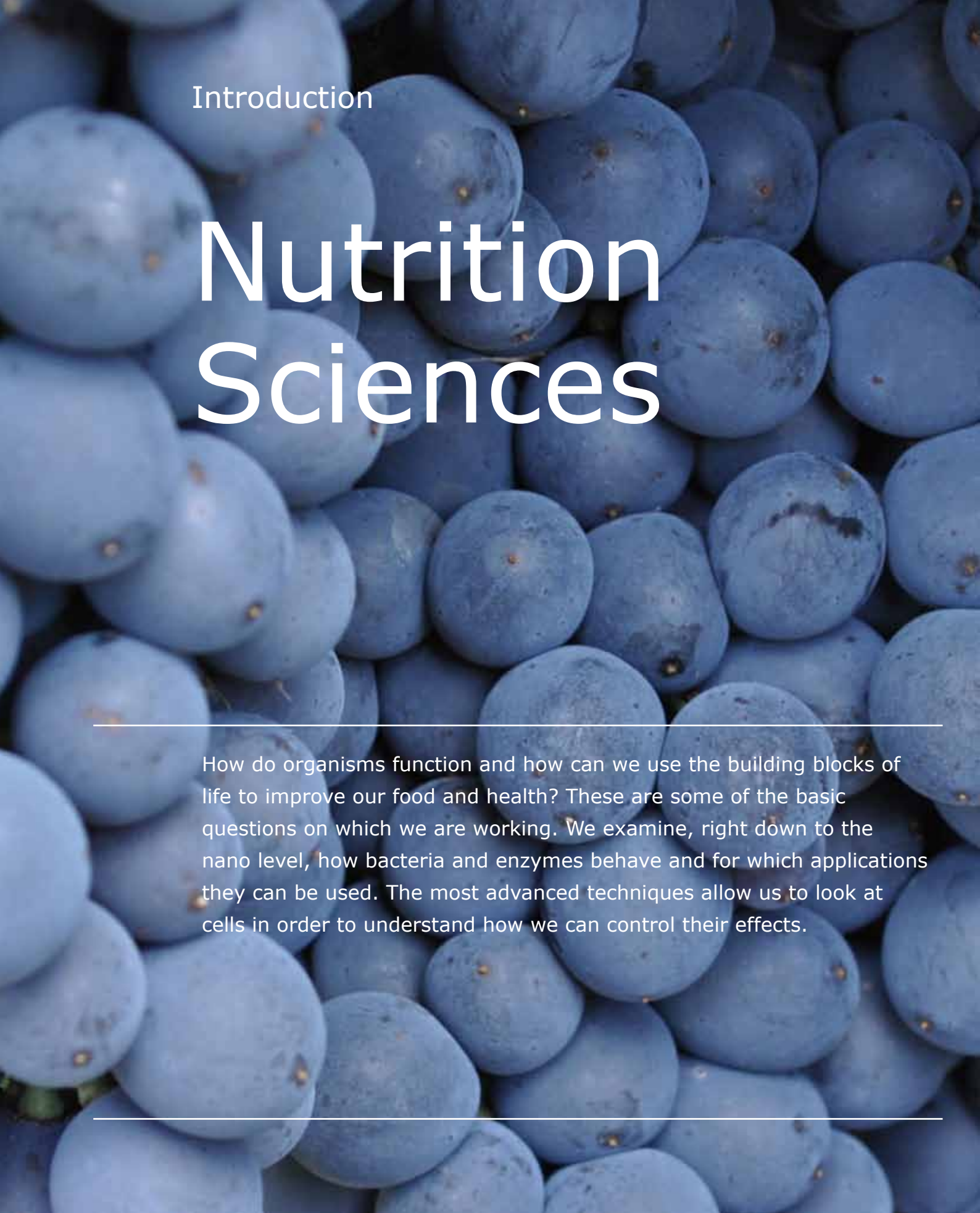


Introduction

Nutrition Sciences

How do organisms function and how can we use the building blocks of life to improve our food and health? These are some of the basic questions on which we are working. We examine, right down to the nano level, how bacteria and enzymes behave and for which applications they can be used. The most advanced techniques allow us to look at cells in order to understand how we can control their effects.

Researching the effects of food

How can people stay healthy as long as possible?

Many developing countries face a major problem with the paucity of good and varied nutrition. Meanwhile, in the Western world an increasing number of people are suffering from obesity, diabetes and cardiovascular diseases. Frans Kok, Professor of Human Nutrition: 'Wageningen UR is researching the effects of food on health in both worlds, based on the key issue: How can food help us stay healthy as long as possible?'

The United Nations aims to have 500 million fewer people living in extreme poverty by 2015 and reduce the number suffering from hunger by 300 million. Wageningen UR is contributing to achieving these goals via various projects. The INSTAPA project is an example. 'This project is aimed at improving basic nutrition in Africa, especially in the region south of the Sahara. We are focusing specifically on children under the age of two and their mothers – to reduce poverty in those countries it is essential that today's young children develop well.'

We are also studying the relationship between nutrition and the cognitive functions of the elderly

Three strategies

INSTAPA follows three strategies: Looking for varieties of basic crops with a higher level of vitamin A, enriching existing products of these crops, and stimulating mothers to prepare food in such a way that more essential nutrients are preserved. A promising project is the introduction of yellow cassava in Kenya, which has a much higher level of vitamin A than the white cassava commonly used in Africa.

The elderly

Closer to home, Wageningen UR is performing research into nutrition and the elderly, including studying the effects on muscular functions of a protein-rich diet combined with lots of exercise. 'Declining muscle mass and strength is very common among elderly people and determines how fast they become dependent on their environment,' Kok explains. 'We are also studying the relationship between nutrition and the cognitive functions of the elderly. Using MRI research, we measure, for example, which brain images present themselves after ingesting substances such as vitamin B and n-3 fatty acids, nutrients of which we believe have a beneficial effect on cognitive capacity.'

Gelderse Vallei hospital

This research project uses MRI equipment from the nearby Gelderse Vallei hospital, with which Wageningen UR has had an alliance since 2007. 'The cooperation works really well,' adds Kok, who says there is growing interest in tackling malnourishment, a common problem among patients. 'We study what food can do before, during and after a stay in the hospital. This way, patients are better fed when they undergo treatment and recover faster after a procedure.'

Frans Kok - *frans.kok@wur.nl*

How can people stay healthy as long as possible?

Food and epidemiology

For forty years Wageningen UR has been generating insights into the effects of food on people's health, combining research on a molecular, individual and population level. The latter is the focus of Pieter van 't Veer, Professor of Nutrition and Epidemiology.

One of the many studies Van 't Veer's research group Food & Epidemiology is working on involves European food standards. The research is focused on the applied standards for the intake of B12, an essential vitamin to stay healthy. The question is: How much does a person need? The European standards for the intake of B12 vary greatly, as was shown in the doctoral research performed by Wageningen scientist Esmée Doets.

It is important to develop new methods and review current standards based on new insights

Standardised methodology

Van 't Veer was one of the supervisors of her research, which studied the food requirements of population groups. The cause of these varying recommendations is that governments and standardising institutions make a different selection of scientific evidence and have different interpretations of its results. 'It transpired that there was no standard method for determining how much B12 people need,' explains the Professor. 'The current B12 recommendations were mainly based on outdated research results from the 1960s and 70s. The research methods used then have since been superseded. It is important to develop new methods and review current standards based on new insights. We developed a standardised methodology, and governmental organisations such as the WHO are taking over the datasets we composed.'

SLIMMER

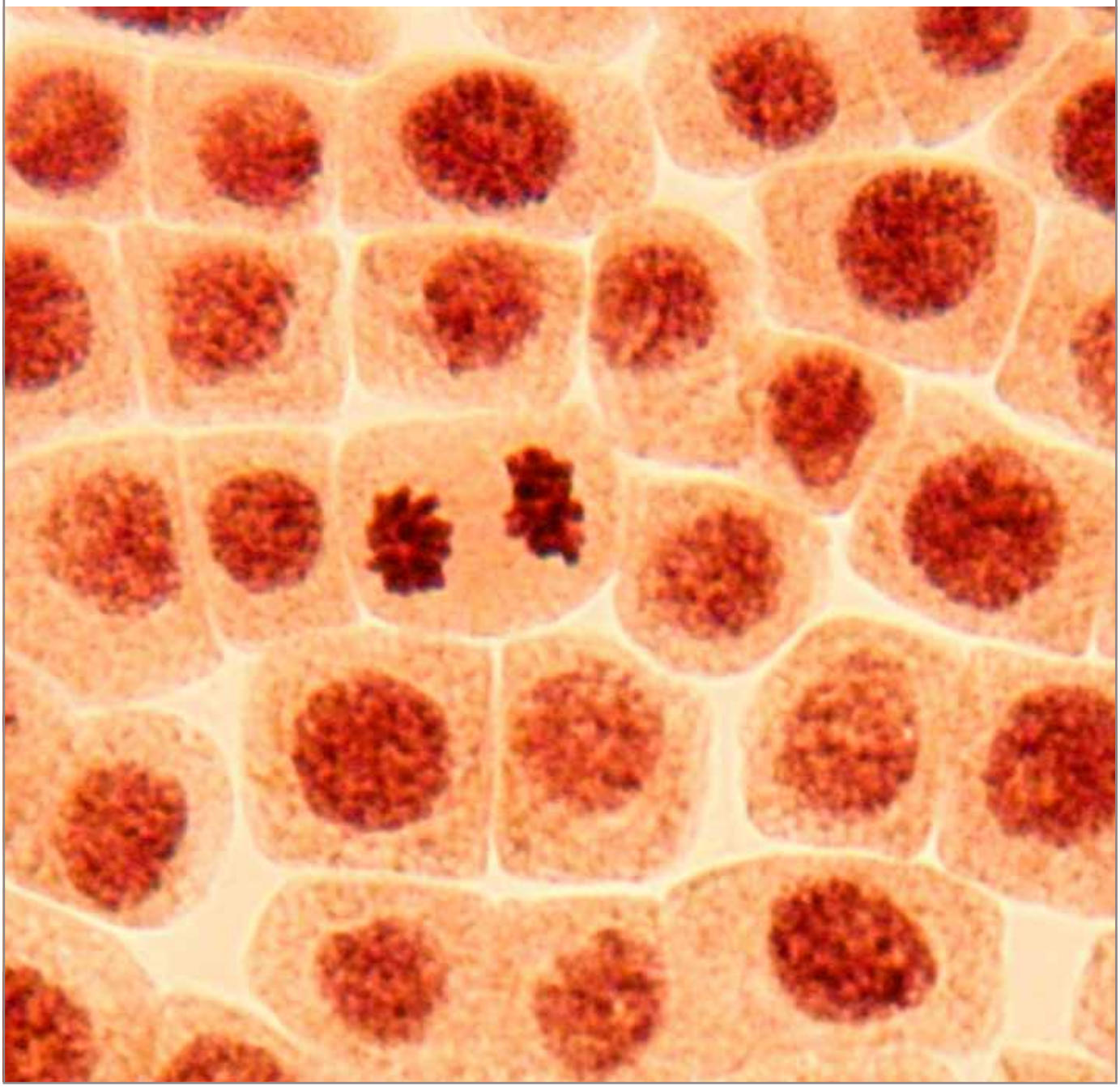
A good example of a bridge between science and practice is the AGORA project, called SLIMMER. This project from the AGORA academic workshop involves a collaboration between the Gelre-IJssel area health authority (GGD) and Wageningen UR. SLIMMER is the practical implementation of the SLIM clinical trial (Study on Lifestyle Intervention Maastricht), in which Wageningen University took part. SLIM has shown – in an academic setting, i.e. evidence based – that diabetes type 2 can be prevented by healthy nutrition and sufficient exercise in nearly 50 percent of cases.

SLIMMER is intended to provide SLIM with practical lifestyle recommendations for people with an increased risk of diabetes type 2. This way, lifestyle interventions that are effective in an academic setting are translated into and tested against daily practice. This is a considerable challenge as it takes a lot of time – and even more so when involving collaboration between local parties such as GPs, dieticians, municipalities, sports organisations and health insurers. Nonetheless, the research provides a great example of how nutrition and sports can improve the health of individuals.

Pieter van 't Veer - *pieter.vantveer@wur.nl*

The interaction between nutrients and genes

NuGO enables – more, wider, better – research



Nutrigenomics, research focused on the interaction betweennutrients and our genes and how this interaction affects health, is a relatively new science. However, thanks to the Nutrigenomics Organisation (NuGO), giant strides have been made in a short period. Michael Müller, Professor of Molecular Nutrition and Nutrigenomics in the Human Nutrition department, is a board member of NuGO.

Most of us can choose to lead a healthy life

With Wageningen UR as coordinator and one of the most active and most renowned members, the NuGO collaboration enables universities and research institutes worldwide to exchange facilities, expertise, tools and data in order to make research easier, more efficient and more effective. Müller is an active nutrigenomics researcher with dreams of 'Nutritional Science 2.0'. 'The major challenge is developing nutritional science in such a way that everyone can stay healthy as long as possible and is protected against disease as a result of optimal nutrition. Of course every person is different and we all react differently to various types of foods. After all, we have tens of thousands of genes in our bodies including a plethora of unique variations and 'faults'. Nevertheless, we always have a choice between one way or another. Most of us can choose to lead a healthy life.'

Standardisation

These many individual genetic differences are exactly why standardisation plays such an important part within nutrigenomics. A major goal of NuGO is therefore the NuGO Bioinformatics Infrastructure wich includes standardised methods, protocols, instruments and data. Müller: 'No matter how complicated it may be (with everyone having their own way of doing things), attaining an effective cooperation and rapport is necessary. We use quite revolutionary software, and databases like the Nutritional Phenotype Database and it is a new way of approaching science: People are no longer working only in their own lab, chasing facts. We now have wide-ranging educational interaction, which also benefits students and research assistants who can now experience early on in their studies just how useful their work really is.' And useful it is indeed.

While nutrition can have negative effects, it is on the whole positive says Müller. 'The key question in nutrigenomics is: How can we make more of our genes? For example: How can we train our liver and intestines to optimally deal with a temporarily increased capacity during Christmas dinner? How can overweight people (due to external circumstances) be returned to their own, non-overweight phenotype and keep this for the rest of their healthy life? Nutrition plays a central role in these issues. And, thanks to NuGO, this role is becoming increasingly effective.'

Michael Müller - *michael.muller@wur.nl*

Nutrition and pharmacology

The healing function of food

‘Many chronic diseases are a direct result of an unhealthy lifestyle. When prevention has failed intervention should be rapid and effective. Combinations of medicinesand lifestyle intervention often meet this requirement,’ according to Renger Witkamp, Professor of Nutrition and Pharmacology.

The research discipline Nutrition & Pharmacology within Wageningen UR is the physiological bridge between the two sciences. It includes research into how nutrition can correct chronic diseases or at least improve the patients’ condition. This begins with studying exactly what nutrition does in the body. Above we mentioned research that shows the anti-inflammatory function of the Angiopoietin-like protein 4. Another example is the field of the so-called endocannabinoïds, which are directly produced, from fats. In brief: chemicals we make ourselves which are responsible for a happy feeling after copious eating, playing on the same receptors as cannabis. Lab research is looking how endocannabinoïds are formed from the food we eat and how we can use them to reward our brains without having to eat a large meal.

The top ten of Dutch medicines includes seven products that combat the negative health effects of an unhealthy lifestyle

Healthy people

The difficult thing is that the ‘healing’ function of nutrition in seemingly ‘healthy’ people is still hard to demonstrate. As a result, there is little urgency for changing the dietary pattern. This is why we are constantly working on the development of new, reliable measuring methods to scientifically establish the health-stimulating function of nutrition. Witkamp: ‘The relationship between nutrition and improved health has been shown for risk groups, for example in the aforementioned study into people who had had a heart attack and also suffered from diabetes. The next step is establishing the function of nutrition in healthy people.’

Pharmacology shift

While medicines will continue to be necessary for acute health problems, pharmacology is increasingly looking towards nutritional science. The principle of ‘one drug fits all’ has often shown to be ineffective and sometimes even harmful. More and more medicines are being developed based on the principle that to restore body functions a gentle ‘multi-target’ approach is often much better. The top ten of Dutch medicines includes seven products that combat the negative health effects of an unhealthy lifestyle.
The downside of these medicines is that they are aimed at a single factor, while chronic disease is often caused by multiple factors. Additionally they often have unpleasant side-effects. Compare it to someone who hits a car engine with a hammer: It may help get the vehicle to run temporarily, but it does not solve the cause of the problem – an unhealthy lifestyle. It is better to turn multiple switches at once. Good nutrition and more exercise, possibly in combination with medication, is often more effective.

Renger Witkamp - *renger.witkamp@wur.nl*

Nutrition and Cancer

Prevention and survival

One in three Dutch people will get cancer, and 30 to 40 percent of all cancer cases are the result of poor nutrition, lack of exercise and overweight. Ellen Kampman, Professor of Diet and Cancer: 'There is a genuine need for knowledge about nutrition and cancer; before and after the diagnosis.'

Globally more than 10,000 studies have been dedicated to the relationship between nutrition and cancer, including a prominent contribution from scientists from Wageningen UR. A large majority of these studies are aimed at prevention, and as a result, a relatively clear picture exists of what we should and shouldn't eat and drink: Plenty of vegetables, fruit and fibres, and a limited amount of alcohol and meat. Overeating should also be avoided: A high Body Mass Index (BMI) means an increased risk of several types of cancer. Some afflictions can also increase the risk of cancer, such as the Lynch syndrome. People with this inherited syndrome have a 60 to 80 percent chance of large bowel cancer (compared to the five percent among the population at large). Is there anything we can do in for these individuals at particular high risk? A recent influential study by Wageningen UR shows that there is. Again, BMI plays an important part: People with Lynch who ensure that their BMI does not exceed 25 can decrease their risk of large bowel (colon) cancer.

In addition to cancer prevention, our research is increasingly focused on nutrition for surviving cancer.

Nutrition during illness

In addition to cancer prevention, our research is increasingly focused on nutrition for surviving cancer. We are looking at the relationship between nutrition and the return of and survival after colon cancer. Another example is a study among women with breast cancer in the research programme of Alpe d'HuZes, which studies changes in fat distribution during and after chemotherapy. Possibly dietary and other lifestyle changes could prevent unhealthy changes in body composition during cancer.

Food supplements

Wageningen UR also carries out research into the functioning of dietary supplements. Nearly half of the Dutch population uses these supplements in the conviction that their diet is insufficiently healthy or to protect themselves from serious diseases such as cancer. The question is: Do these products help? Or do they sometimes have the opposite effect? The research is focused on 'healthy' people as well as on people who use dietary supplements in their cancer treatment to supplement possible nutrient shortages, for example. Recent studies show that a critical attitude towards dietary supplements is justified: The health preventive effects of selenium and vitamin E, for instance, could not be proven

Ellen Kampman - *ellen.kampman@wur.nl*

Wageningen UR one of the leading parties

European food sector needs entrepreneurial spirit

'While the know-how to make Europe *the* innovation hub for food is available, there is a lack of entrepreneurial spirit to develop real innovations using that knowledge. FoodBEST, a Pan-European consortium in which Wageningen UR is one of the leading parties, aims to offer a solution', according to Charon Zondervan, Programme Leader Fresh Food and Chains at Food & Biobased Research.

Since 2008 Europe does at least have a European Institute of Innovation & Technology (EIT) which is situated in Budapest. The organisation is authorised by the European Commission to finance Knowledge and Innovation Communities (KICs), consortia that bring together expertise and best practice within sectors and inspire businesses to develop innovative new products. There are currently three KICs, active in the Climate, Energy and ICT sectors. The idea is for FoodBEST to develop into a KIC focused on areas such as food security, sustainable food products and food & health. Whether such a 'Food KIC' will be established will be decided by the EC in late 2012.

Brave enough to step away from what they know and develop genuinely innovative revenue models

Transferring intellectual property

Zondervan sees it as a matter of considerable importance to tackle the European 'knowledge paradox'. 'The social issues related to food such as obesity are well-known, as is the environmental impact of the food industry, the largest of all industrial sectors. Although there is ample knowledge available in Europe to solve these matters, the organisation to bring it together is lacking. And there are also too few companies which are brave enough to step away from what they know and develop genuinely innovative revenue models.' As an example, Zondervan lists the promising production ideas that gather dust on the shelves of major food companies because the estimated return on investment is too low. 'This is a terrible waste.'

Entrepreneurial spirit

The goal of FoodBEST is to establish these types of missing links, with the main challenge being to increase the innovative strength of small and medium-sized companies. 'We want SMEs to be introduced to new technologies and business models. In short, our goal is to stimulate the entrepreneurial spirit within the European food sector.' With justifiable pride, Zondervan cites the example of Hoogesteger, a Dutch fruit juice manufacturer with which Wageningen UR has been working for 15 years. 'Together we developed a micro-pulse treatment that keeps fruit juices fresh for 21 days, without losing their flavour or nutritional value. Another success story has been Ojah, a spin-off from Wageningen UR that is marketing a vegetable product with a flavour and texture which is very similar to chicken. These are examples of companies that actually want to make a difference.'

Charon Zondervan - *charon.zondervan@wur.nl*

Restaurant of the Future

Eating examined

How do people choose what they eat? Marchel Gorselink, Managing Director of Restaurant of the Future: 'The answers to this and other related questions are being sought by scientists in Wageningen UR's Restaurant of the Future, a centre for physiological, sensory and real life food research.'

The physiological laboratories carry out advanced studies into smell, taste and chewing behaviour in relation to consumer emotions. A recent example is research into the influence of smell on the consumption of custard, during which scientists introduced scents into subjects' noses with a tube. The conclusion was that, the more intense the smell, the smaller the bites people take.

The Restaurant of the Future is an initiative by Wageningen University in cooperation with Sodexo, Noldus IT and Kampri Groep

Linking data

The second branch, sensory research, basically uses two different types of research groups. One is made up of panels of consumers trained to distinguish product characteristics such as smell, taste and texture with great accuracy. The other consists of average consumers for indicative research. Combining data from the different sensory studies of different groups, companies can acquire a great deal of interesting information. Considerable attention is paid to specific target groups. If we look at the future of product development, say, ageing people represent an important consumer group for the food industry. Consumer perceptions of bread with increased protein content were recently investigated in this framework. The study showed that both average consumers and senior citizens with a good sense of smell barely reacted to the health claims and even found the bread less tasty. Senior citizens with a weaker sense of smell responded positively.

Real life

The third category of research takes place in the restaurant itself. Cameras observe how people move and what they focus on, while the cashiers record what the guests buy in terms of nutritional values. The eating behaviour of restaurant guests and which foods they throw away is also observed. Gorselink: 'Real life research is a valuable complement to physiological and sensory analysis. A study conducted in the latter field, which looked at the effects of salt reduction in soup and bread, found that less salt tends to be considered less tasty. But real life research in the restaurant showed that a gradual salt reduction of up to 25% is accepted by consumers.'

On location

Real life research also takes place elsewhere such as in homes, supermarket and nursing homes. A pilot study in two nursing homes in Brabant, for example, showed a correlation between good nutrition in a cosy atmosphere and weight gain in undernourished senior citizens.

Marchel Gorselink - *marchel.gorselink@wur.nl*

Introduction

Biobased Sciences

Contributing to good health through better nutrition. The main challenge is to keep everyone as healthy as possible by promoting the right diet. Thanks to advanced research, our knowledge about how food affects the human body is continuously improving.
We conduct research both at the cellular level and on the scale of the individual and the entire population, both separately and combined.

Clean water, nutrients, energy and bioplastics

Water treatment as a factory

The Biobased Economy revolves around biomass. Biomass is also found in wastewater, together with valuable nutrients. Currently, however, these valuable resources are not being used, which Huub Rijnaarts, Professor of Environment and Water Technology considers a waste.

'We are currently working on new technologies to make wastewater suitable for reuse and to extract nutrients and energy from the water. For the production of artificial fertiliser, for example, nitrogen and phosphorous is extracted from the atmosphere or the subsoil. Yet, despite the global shortage of phosphorous, it is returned unused to the ecosystem in agricultural and consumer wastewater.'

Our aim is to extract the nutrients and return them to where they are needed

Towards an anaerobic technology

'Our aim is to extract the nutrients and return them to where they are needed: For the production of biomass in agriculture,' explains Rijnaarts. 'We can convert the organic substances in wastewater into useful materials such as biodiesel, methane gas, electricity, polymers or bioplastics.'. As things stand they all disappear into the waste incinerator in the form of sediment. The current water treatment process is based on oxygen and microorganisms. 'Our alternative is an anaerobic, i.e. oxygen-free, treatment technique via the creation of conditions similar to a cow's stomach.'

Separating wastewater in the home

'We use microorganisms to produce methane gas or other substances from biomass,' continues Rijnaarts. 'After being treated the water still contains phosphorous and nitrogen, which is then extracted using a different technique.' A number of research questions remain. To efficiently extract water, gas and nutrients, it will be necessary to separate household sanitary wastewater from laundry and rainwater. Tests are currently being conducted on this subject, while practical experience has been gained at 32 houses in Sneek (NL). 'We are also looking for a technology which can be used to extract micro-contaminants, medicine traces and harmful viruses and bacteria from the wastewater from industry, toilets, kitchens, hand washers and showers.'

Huub Rijnaarts - *huub.rijnaarts@wur.nl*

Algae cultivation: Technology with a future

AlgaePARC as a catalyst for further research

Which components are produced in algal, fungal and yeast cells and how can we influence the process to produce bio-products? This is a typical question for Rene Wijffels, Professor of Bioprocess Engineering. 'Algae cultivation is a field of application that has grown in importance,' he says.

'Algae can accumulate lipids, which makes them eminently suitable for the production ofbiofuels.' The opportunities presented by algae are promising, not least due to the considerable industrial interest in sustainable production. 'Moreover, no soil is needed to produce them and there is no competition with food production.'

Algae purify water and produce oxygen, protein and oil from light

Testing and comparing cultivation technologies

The downside is that the development of the technology has yet to be completed. 'We started as pioneers in 1997, and there is still much to be done before it becomes an industrial process,' Wijffels explains. 'Research is currently being carried out together with many companies in Wageningen, Leeuwarden, Vlissingen and in Spain. But more large research programmes are needed, with support from the industry.' A major step forward was taken with the building of AlgaePARC (Algae Production and Research Centre), a 700 m^2 complex in the direct vicinity of the campus in Wageningen. Here scientists are testing four different cultivation technologies and comparing them with each other. A closed system seems to be the most promising according to the calculations, says Wijffels. 'Our dream is to place such a solution as a stand-alone system in the desert, for example.'

Using all components

The AlgaePARC represents the translation of laboratory research into practice and forms the bridge to actual algae applications. Wijffels: 'The research was initially driven by the oil industry, but we also want to extract other components from algae. Algae purify water and produce oxygen, protein and oil from light. If we can combine all of this, the result will be a business case, the simultaneous production of food, chemicals, materials and fuels. This is why so many companies are working together on this project. We are also working with partners on specific products and AlgaePARC is an important catalyst for this as we now have something to show.'

Rene Wijffels - *rene.wijffels@wur.nl*

Small-scale biorefinery the most attractive option

Biomass cultivation offers farmers new opportunities

The Netherlands is aiming to replace thirty per cent of its fossil resources with biomass by 2030, an ambitious target for which a great deal more biomass will be needed. How can we cultivate this in an economically responsible way and what is the most efficient way to extract the valuable raw materials? 'There is a pressing need for research as fossil fuels are often much cheaper,' says Johan Sanders, Professor Valorisation of Plant Production Chains.

Grass contains proteins for pig feed, fibres for paper production and other substances too.

'It's important to start out by deciding what you hope to achieve. There are five applications that call for large volumes and which are rising in value: Electricity, liquid transport fuels, bulk chemicals, animal feed and food. Fractions that are isolated from plants often have an enormous value in themselves, sometimes even higher than those originating from the petrochemical sector.' Separating substances from plant materials via biorefinery makes it possible to use each component at its highest value. 'This is important as it enables farmers to generate new income from plant materials,' adds Sanders. 'Without taking the plant apart, they only make use of the highest value of a single component.'

Small-scale pays

As a rule of thumb we can say that the larger the factory, the cheaper the product. This doesn't hold true for biorefinery, however, where small-scale biorefineries yield benefits throughout the entire chain. But how to set them up? 'There have already been success stories in this area,' says Sanders. 'In Africa there are four mobile factories in containers where valuable substances are extracted from cassava. In the Netherlands we are working on mobile grass processing as grass contains proteins for pig feed, fibres for paper production, and other substances. A demo project for a corn to ethanol factory has been started up in Lelystad, producing ethanol at a lower cost than American factories that are 200 times larger. And in the laboratory we now have 'proof of principle' for the crystallisation of sugar in a factory that serves only 500 ha.'

Ultimately, it is important to help farmers to retain plant components that enhance soil fertility in the field. The farmer becomes the producer of biomass for all applications. 'In this way we save the highest percentage of fossil fuels per hectare,' Sanders concludes.

Johan Sanders - *johan.sanders@wur.nl*

Heading for a prosperous green future

With an absence of established players in the Biobased Economy, new parties have the chance to develop the market and make a profitable business. The key to gaining a competitive advantage is know-how and innovation. The Netherlands is playing a leading role in the development of this green economy, with Wageningen UR at the cutting edge. Erik van Seventer, Business Unit Manager Wageningen UR Food & Biobased Research, demonstrates this with a number of products made from biomass at Wageningen UR.

New developments are occuring at a rapid pace

Biodegradable expandable polylactic acid (PLA), a green plasticiser, durable European wood using a new class of biomass based binders, and biobutanol made of wet biomass such asgrass. 'New developments are occuring at a rapid pace,' he says. 'This can be attributed to Wageningen UR's broad knowledge of organic raw materials, production processes, and biobased chemicals and materials, as well as issues related to agri-production and land use biodiversity.'

Making the most of plants

Production in the Biobased Economy centres on the biorefinery of crops. Biorefinery enables us to make the best possible use of plants, with the first priority being food production. Remnant constituents of the plant are used for the production of materials and chemicals, and waste refuse can be used for the production of bio-energy.
An important success factor for the green economy is to properly combine large-scale and small-scale processing. There are countless biomass resources in world and an initial processing step close to the source is vital if part of the yield is not to be lost in transport costs.

Research, advice, initiation and innovation

According to Van Seventer, Wageningen UR plays an important role as it oversees the entire chain. 'We understand agriculture and develop the know-how needed to use green commodities more sustainably and effectively, and help close the loop between waste and production. We work together on the development of knowledge and innovation with private companies, other research institutes and the public sector.
The Biobased Economy is a global development that is ideal for the Netherlands, which has a strong foundation in chemicals, agriculture and logistics as well as a high degree of commercial confidence. Wageningen UR is naturally developing into a leading international R&D centre for the development of the Biobased Economy and biobased products. In doing so we are enhancing the prospects for green prosperity.'

Erik van Seventer - *erik.vanseventer@wur.nl*

Helping policymakers make the right choices

Bioplastics are often more sustainable than biofuels

We can already do a great deal with biomass. But how do we translate all the technological alternatives provided by the Biobased Economy into policy? Seeking answers to this vital question, Harriëtte Bos, Programme Manager Policy Support Biobased Economy, Food & Biobased Research, and her department conduct policy support research for the Dutch government and various companies.

We can help policy-makers make the right choices

'Policy and technology are far apart and by bringing them closer we can help policy-makers make the right choices. This is only possible, however, if they understand the underlying technologies and my mission is to explain them in a way that laymen can comprehend.'

Publications and research

One of the key tools for making technology comprehensible and accessible is the internet. 'A great deal is happening in the Biobased Economy,' Bos continues. 'Our special *Groene Grondstoffen* (green raw materials) website contains factsheets that clearly and concisely explain relevant subjects. We also publish a regular series of booklets on subjects such as biorefinery, bioplastics and algae.' In addition to its publishing activities, the department carries out research too. One key topic is the sustainability of products made from biomass. 'We conducted a study, comparing five crops from which sugars can be extracted. These sugars form the basis for various products, including ethanol and bioplastics.'

Assessing chains

But what is the most sustainable choice? How much CO_2 is released and how much energy does it take to make a given product? 'It appears to be smarter to make bioplastics from sugars rather than fuel. Sugar beet is an interesting crop for this purpose as it has such a high yield per hectare. Wageningen UR is also studying the economic and technological feasibility of various production chains. It has emerged that biorefinery – the production of both high value and low value products from the same biomass – makes the chain more economically attractive. 'We have assessed a number of chains and made an internet tool that enables people to carry out their own model calculations and establish the effect of specific choices on various products.'

Hariëtte Bos - *harriette.bos@wur.nl*

Bioplastics to replace and outperform traditional plastics

Plastics 2.0

‘Foam, plant pots bags; a wide range of products are already made with bioplastics, and there is a good chance that they had their origins in Wageningen,’ says Christiaan Bolck, Programme Manager Biobased Materials, Food & Biobased Research.

‘Wageningen UR Food and Biobased Research studies the production of chemicals, materials and energy from biomass. The research on materials results among others in high-quality fibrous materials from alternative biomass sources for products such as paper and textiles. But the main focus is on biobased plastics. We use biomass to produce polymers. We then add additives and use the right processing to develop biobased materials and products with the right properties like heat resistance and impact strength for a specific application.’

Using the functionalities that nature offers us

Closing the cycle

The developed products find their way to sectors such as agriculture and the packaging industry but also into household appliances and automotive applications. A common misunderstanding is that biobased plastics are always biodegradable. The term ‘biobased’ refers to the raw material that was used to produce it, not the biodegradability. ‘However some biobased plastic are compostable and some not,’ Bolck explains. ‘The choice for a material also depends on the wishes and demands for the type of product. We are working on various types of plastics. For example, it would be practical if potato bags could be disposed of in the green waste bin with the potato peels. Mobile phone casings can be collected and recycled or used to produce energy. The main thing is to close the cycle.’

Outperform traditional plastics

Wageningen UR has a very extensive knowledge of biobased plastics. In partnership with industry, a wide range of products is being developed that subsequently find their way onto the market. ‘We can make almost all plastics we know biobased, and sometimes even with a better quality. It is becoming the substitute for traditional plastics,’ concludes Bolck. ‘And it may happen sooner than you think.’

Christiaan Bolck - *christiaan.bolck@wur.nl*

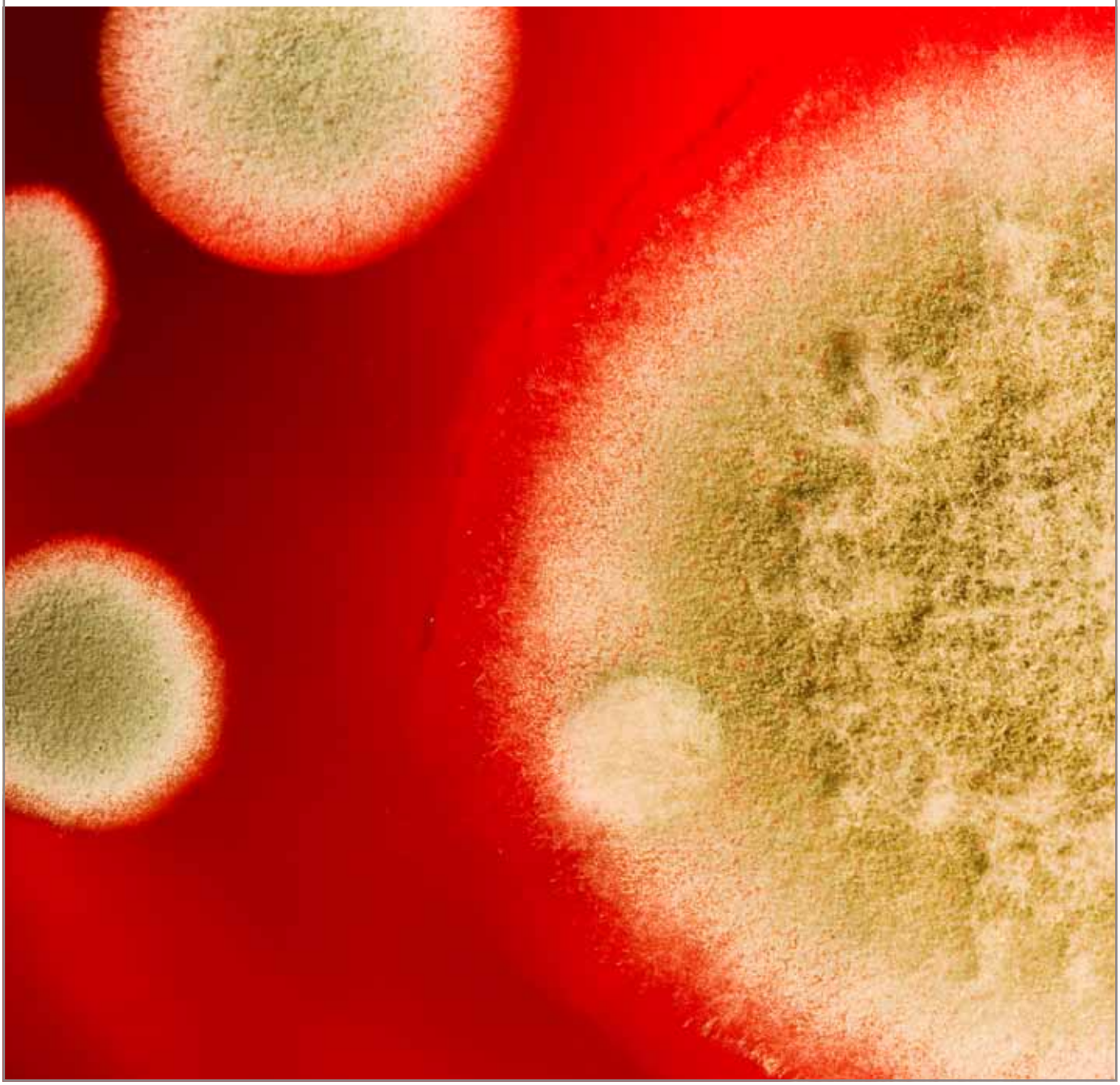
Introduction

Food Sciences

The production and processing of our food has become strongly industrialised over the years. This has resulted in many benefits such as improving the quality, attractiveness and safety of our food. It has also placed enormous demands on the logistical chain from harvest to consumer. Through multidisciplinary research, we contribute to further enhancing the quality of our food.

Much of what we eat is influenced by tiny creatures

Good bugs, bad bugs



Although we may not think about it every day, much of what we eat is influenced by tiny creatures. Marcel Zwietering, Professor of Food Microbiology studies microorganisms and their relationship with the food we consume.

Down to the molecule

Zwietering and his colleagues work on different scales. The first consists mostly of studies into the stress response of bacteria on a molecular level. Sophisticated equipment at Wageningen UR observes right down to the molecular level the reactions of bacteria to being 'pestered,' e.g. by heating, disinfecting or being exposed to salt. After a bacterium has been given a shock, the scientists try to gauge its response. 'Some bacteria arm themselves against the threat. And in extreme cases, changes occur in their DNA that render them permanently resistant.'

After a bacterium has been given a shock, the scientists try to gauge its response

Physical distribution

An example of larger scale research focuses on the physical distribution of contaminated food products within batches of food. The abovementioned EHEC outbreak made painfully clear the difficulty of tracing the source of a contagion. 'An infection with one thousand such microorganisms, say, could cause considerable damage. Suppose you had a batch of 1000 kilos of vegetable seeds and the harmful microorganisms were spatially highly concentrated. The odds are that examining ten samples of ten grams each would not detect them.'

Ninety-seven percent certainty

Zwietering and his colleagues examined a contaminated batch of powdered milk to see how the traceability of harmful microorganisms could be improved by taking samples more effectively. 'We first analysed how the contamination had spread in the milk. Then we established the likelihood that the contamination would be found with various theoretical sample distributions. With the former standard, ten samples of ten milligrams, there was a 70 percent chance of detecting the contamination. With our data, we determined that a new sampling scheme of 30 times 10 grams increased the probability of finding the bacterium to 97 percent – a major improvement, although a small possibility remains of missing it.'

Many of the studies at the molecular level, which try to establish the Achilles' heel of undesirable bacteria in food products, are organised within the TIFN institute, which brings together the Dutch government, businesses, research institutions and universities. Studies into improved sampling methods are financed by the European Chair in Food Safety Microbiology, a special department set up by the industry.

Marcel Zwietering - *marcel.zwietering@wur.nl*

Reduce, reuse, recycle, rethink

Aiming to reduce food waste by half

‘In the Netherlands alone, several billion euros worth of food is thrown in the bin or used for unnecessarily low-grade purposes every year. Solutions for reducing waste are within easy reach, with reductions of between 40 and 50 percent possible’, says Toine Timmermans, Programme Manager Sustainable Food Chains, Food & Biobased Research.

Consumers are the main culprits. On average, people buy 20 percent too much food and cook 30 percent too much for the evening meal. Although a major challenge, Toine Timmermans is convinced that the wasteful behaviour of consumers can be changed. ‘Imagine products that keep for longer thanks to mild preservation techniques, or portions for one-person households. We can also provide better information on the actual shelf life of products to give consumers a push in the right direction.’

People buy 20 percent too much food and cook 30 percent too much for the evening meal

Saving money

According to Timmermans, it is ultimately possible to reduce waste by 40 to 50 percent, with companies and institutions paying increasing attention to the problem. A practical example is a new meal concept deployed by healthcare institutions to save tens of thousands of euros a month: Patients now get their food served directly on the spot and do not need to choose their meal days in advance. Between 36 and 48 percent of the food used to be thrown away, while the new concept reduced this to a mere 2.2 percent. And if our suspicion that better food leads to faster recovery is confirmed, the ultimate benefit will have been much higher still.’

Model

The concept is being introduced at several other institutions. In the TI Food & Nutrition project called Reduce Spoilage, scientific knowledge and a decision-supporting model were developed to support companies in implementing the most promising measures for improvement and innovation. The focus is on fresh products, such as vegetables, bread and meat. The project was designed in partnership with the Dutch food industry and supermarkets.

FUSIONS

Research and innovation will provide a major contribution to slashing food waste in half by 2025. This is the ambition of FUSIONS, a European consortium of 21 universities, organisations and businesses. Coordinated by Wageningen UR Food & Biobased Research, FUSIONS is a project within the FP7 EU me for research and innovation. ‘By innovation we mean clear labelling of the expiry date on a product or social innovations that lead to creative solutions in society,’ Timmermans says. ‘FUSIONS begins with clear definitions and a common methodology to assess the magnitude of the problem.’

Toine Timmermans - *toine.timmermans@wur.nl*

Looking for new separation techniques

Identifying opportunities and developing technology

Plants are becoming increasingly attractive for purposes other than food for people and animals. Chemicals, biofuels and materials, nowadays also originate from biomass nowadays. It is difficult to increase production because we have reached the limits of land and water use. ‘That means that we have to work towards better separation techniques to get more out of the plant,’ says Remko Boom, Professor of Food Process Engineering. ‘The current separation techniques adversely affect the quality of the proteins, so we’ll have to come up with something else.’

The goal is to separate all materials in a plant as efficiently as possible

Retaining protein functionality

Boom is achieving notable success with the development of a new separation technique for wheat flour. Dutch wheat is grown mainly for its starch, which is processed into animal feed. But wheat also contains other useful substances. The goal is to separate all the materials in a plant as efficiently as possible. ‘The trouble is that the existing techniques always have an adverse effect on the protein functionality. We’ve discovered a new, sustainable (and very fast) separation method that not only requires less water and energy, but also retains the protein functionality. The time has now come to further optimise the process. And we’ll be looking into the question of whether we can also use this technique for other plants.’

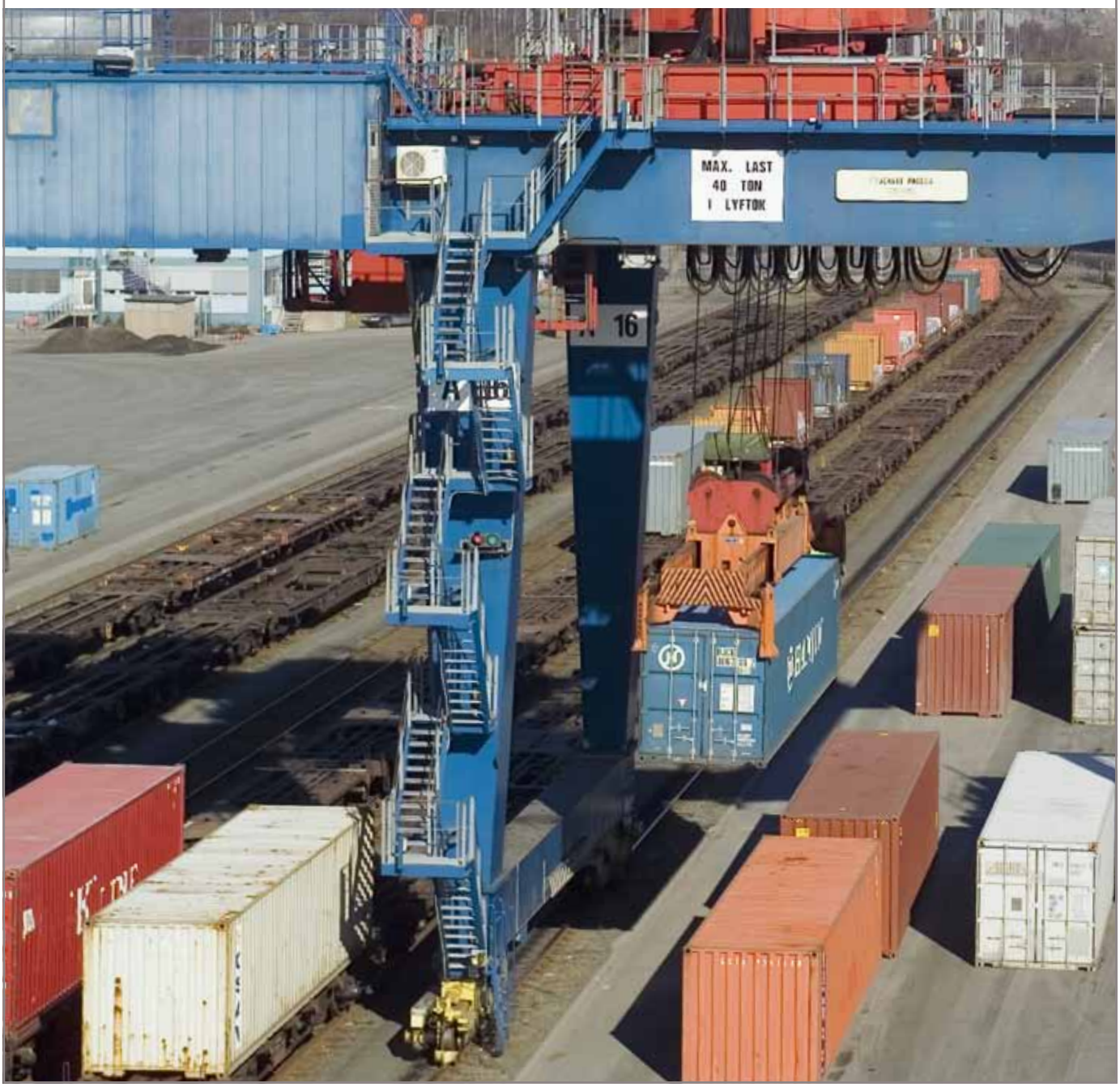
First food, then fuel, materials and chemicals

Boom is now looking for new protein sources for human foods. He has already succeeded in using dairy protein to make a fibre similar to that of meat, which is also retained after cooking. Another idea is to give cultivated fish such as salmon a vegetarian diet. The animal protein that is saved can be used for human food instead. Algae also present attractive options. ‘I want to find out how we can initially extract food from plants and algae. We have to look for opportunities and then develop process technologies for using alternative biomass in the food chain and in the remnant streams for biofuels, materials and chemicals.’

Remko Boom - *remko.boom@wur.nl*

Alternative cargo routes must be found

The right agro-products at the right time and place



Transport by cargo is expected to increase by around 30 percent in 2030 (compared to 2005) and to 80 percent in 2050. It would be preferable if half of this increase would be off-road, which according to the EU is necessary is a prerequisite in terms of sustainability and the environment. Dutch trade organisations and the Dutch government agree due to the fall in the number of lorry drivers. This is one of the challenges faced by Joost Snels, Senior Project Manager Supply Chain Management within Food & Biobased Research.

Why get products from afar if they can come from your own backyard?

Supply Chain Management is part of the larger Fresh Logistics Management unit that aims to gets the right fresh agro-products to the right place in the required quantities at the right time. 'This is an issue on a global level – how do we provide the world with food – but also on a regional and local level. Why get products from afar if they can come from your own backyard? The starting point is to have the shortest possible transport lines.'

Hubs

As a good example, Snels cites the COFCO project for the China Oil & Foodstuffs Corporation. 'Enormous production and logistics centres (or hubs) have been developed to supply food to large cities such as Shanghai and Beijing, which efficiently combine as many local and regional as well as overseas products as possible and distribute them down to the inner-city micro-level.'

The COFCO project was realised by a Wageningen UR-wide team. 'This is the unique strength of Wageningen UR: Sharing and integrating knowledge. We want to realise a similar successful hub concept within a logistic Vers Kernnetwerk in Europe as well. There are already a few naturally developed examples in the Netherlands, such as Agri Poort A7 in the province of North Holland and Fresh Park Venlo. The trick is to structurally shape the natural elements such as location and existing infrastructure.'

It can be done

The results of the initial exploratory research into alternative agro-transport routes and networks were presented at the Floriade event nearby Fresh Park Venlo in September 2012. And the response was enthusiastic: 'It can be done: The train ('Green Rail'), short-sea and inland shipping industry should be able to handle the capacity of the volumes produced in the Netherlands and those that are imported via the Port of Rotterdam. But before then, there are still various aspects that require study.'

Joost Snels - *joost.snels@wur.nl*

About the health, attractiveness and sustainability of our food

Looking for better alternatives

In the Western world we can choose from an enormous range of food products at relatively low prices. Nonetheless, many people are worried about the health, attractiveness and sustainability of our food. Various research projects within Wageningen UR have clear links to this social trend as Tiny van Boekel, Professor of Food Technology, explains.

An example of research focused on the health theme is the study into glucosinolates, substances that are naturally present in cabbage varieties such as broccoli. 'Glucosinolates have the characteristic that they produce enzymes in the liver that breakdown carcinogenic compounds in the body,' says Van Boekel. 'We studied the extent to which glucosinolates change between planting and when consumers prepare the food.' One of the more remarkable results of the study into glucosinolates is that consumers would be better off cooking their broccoli in the microwave instead of boiling in a pan. 'Very little water is used in the microwave, considerably reducing the loss of glucosinolates', reveals Van Boekel.

Consumers would be better off cooking their broccoli in the microwave instead of boiling in a pan

Meat substitutes

Other studies are focused on the development of vegetable, protein-rich products that can serve as substitutes for meat. Van Boekel: 'The production of meat is relatively bad for the environment, generating a great deal of greenhouse gas and consuming lots of water. Moreover, it is a highly inefficient type of food production with only five to ten percent of the required cattle feed being transferred into food. The rest is lost.'

Insects

The scientists face two main challenges. The first is developing meat substitutes that result in a similar intake of protein, iron and vitamin B as meat products. The second is to find alternatives that have the same 'bite' as meat. 'Although there is still a long way to go in both areas, we have made considerable progress over recent years,' Van Boekel explains. Additionally, insects seem to have lots of potential as a food source. They convert food into protein in a much more efficient way than cattle and grow on waste flows that we cannot use ourselves, such as those from the food and hospitality industry. As a result, these waste flows gain economic value as they are converted into high-quality protein sources.'

Although three-quarters of the global population eats insects, a plate of fried grasshoppers or a salad with mealworm garnish can count on very little enthusiasm from Western consumers. 'There is a substantial psychological barrier,' says Van Boekel. 'This is why we are performing research into processing insects in food products in order that they are no longer recognisable to consumers.'

Tiny van Boekel - *tiny.vanboekel@wur.nl*

Improve the sustainability while maintaining the quality of food

Fresh for longer

How can we improve the sustainability of products on supermarket shelves while maintaining food quality? This is a highly topical question for food technicians, says Ariëtte Matser, Project Coordinator Fresh Food and Chains, Food & Biobased Research.

There are promising new mild preservation methods, such as high pressure, pulsed electric field processing, cold plasma and advanced heating. Wageningen UR Food & Biobased Research examined the applicability of these methods together with 37 other universities, research institutes and industries.

We now understand better the effects that mild preservation techniques have on

The project partners worked together for five years within the framework of the European NovelQ project. Their objectives were to develop new preservation methods and environmentally friendly and inexpensive – or eco-efficient – production based on new preservatives and packaging concepts. During this multifaceted project, all aspects of the food chain were highlighted, including food safety, business applications, and consumer perceptions. NovelQ was coordinated by Food & Biobased Research.

Knowledge gap

According to Ariëtte Matser NovelQ has greatly expanded the available knowledge of
mild preservation and packaging methods as related to product quality. 'We now understand better the effects that mild preservation techniques have on, for example, food structure and the chemical composition and inactivation of microorganisms.' In addition, the project has resulted in 135 scientific publications on new preservation methods, 60 publications in professional journals for the food industry, and 20 public workshops in different European regions.

Industry Advisory Platform

The Industry Advisory Platform (IAP) is an important key to the success of NovelQ. This platform of 89 companies – including food producers, equipment suppliers and other interested parties – acted as a sounding board for the scientists. They supplied feedback on the new preservation methods based on their daily practice. Food & Biobased Research organised workshops and meetings, and took care of newsletters and the NovelQ website, for the IAP members. In addition, it developed business cases and a decision support tool for the selection of the most suitable mild preservation method for their product.

Ariëtte Matser - *ariette.matser@wur.nl*

Working on ‘smart’ agro-product chains

Getting a firm grip on quality

Before roses reach the vase or avocados the fruit bowl, they will often have travelled considerable distances, says Henry Boerrigter, Market Theme Leader Fresh Food & Chains, Food & Biobased Research. What happens on the journey and how this affects freshness, shelf-life, flavour and nutritional value is largely a grey area, so producers are unable to guarantee their products from A to B.

First of all, we need the basic data for a consignment

However, a guarantee of this kind would be of enormous benefit to producers, consumers and all the intervening links in the chain. Wageningen UR is working on 'smart' agro-product chains in order to get a better grip on quality.
Three essential elements go to make up a smart agro-product chain. Henry Boerrigter: 'First of all, we need the basic data for a consignment: which variety is it, what happened during growth and harvest, which protective measures are being used (packaging, cooling)? In other words: how was the quality when the product left the premises? The next step is to monitor the consignment as it passes through the chain. We could do this using RFID with smart sensors, for example. The third element involves a model; a mathematical formula that allows you to determine residual quality on the basis of the first two elements. In this way, you can monitor the quality of a product at any point in the chain and make informed decisions about the next part of the chain. Can a consignment from Chile, for example, continue on its path to Russia or would Germany be a better final destination?'

Q-cotrans

Smart agro-product chains are still being developed, but work is so advanced that Boerrigter needs no more convincing of the system's worth. 'Several recent studies have boosted my confidence in the system. They include Q-cotrans: quality management in co-modal transport chains. This piece of research involved monitoring roses from Kenya from the grower to the retailer. We were able to make a fairly accurate prediction of the residual quality at every point in the chain.' There is a lot of scientific, social and commercial interest in the current exploratory studies. The next phase involves broadening and deepening the concept to show that the system can also be valuable for other lines and products.

Pasteur

Together with previous research conducted by Food & Biobased Research, Q-cotrans is making a major contribution to the European Pasteur project. Aim: to develop a new generation RFID chip that can be used with a whole range of sensors.

Henry Boerrigter - *henry.boerrigter@wur.nl*

Introduction

Biomoleculair Sciences

The biobased economy is gradually taking over from the fossil-fuel economy. One characteristic of this new paradigm is that food, chemicals, materials, fuels, electricity and heating are all produced sustainably from renewable resources. Around the world, our research lays the foundations for technological breakthroughs and successful biobased products.

Nutrition and microbiology

From mice to men

Obese mice have bacteria in their intestines that seem to digest foods more efficiently. Willem de Vos, Professor of Microbiology: 'The bacteria draw more energy from nutrition, causing the mice to gain weight more easily.'

Research in the US has shown that transplanting these bacteria to germ-free mice led to their fat percentage also increasing. Researchers at the Laboratory of Microbiology now hope to use this fascinating information for the quality of life of human. With colleagues from the Amsterdam Medical Centre the Laboratory of Microbiology has found that patients with type 2 diabetesmetabolic also have different microbiota. Moreover, they showed that the insulin-resistance of these patients could be improved by replacing their microbiota by that of healthy and lean donors. These transplantation results demonstrate that the intestinal microbiota have a causal effect in metabolic syndrome. While it is possible that the intestinal bacteria process foods differently, it is also possible they signal differently to the host.

Patients with type 2 diabetesmetabolic have also different microbiota

Step by step

The molecular mechanisms underlying health-promoting roles of the intestinal microbiota are subject of intense research, a new and undeveloped field that requires a step by step way. The recent discovery by the MetaHit consortium (Laboratory of Microbiology is a prominent participant) that people can be grouped based on their intestinal enterotypes is probably a major one. Enterotypes can be seen as common networks of the microbial groups in our intestinal tract. It has been envisaged that people can be classified based on these enterotypes and hence could be showing similar responses. Another significant breakthrough is the discovery, by the Laboratories of Microbiology and Host-Microbe Interactions of Wageningen University with the TI Food & Nutrition, that microbiota talk to our genes. Lactobacilli that were introduced in the small intestine were shown to consistently affect gene expression and notably the immune response. If this communication could be further understood, it could be steered, for example by means of probiotic interventions such as those with Lactobacillus rhamnosus GG that contains specific surface determinants that stick out and interact with our intestinal mucosa.

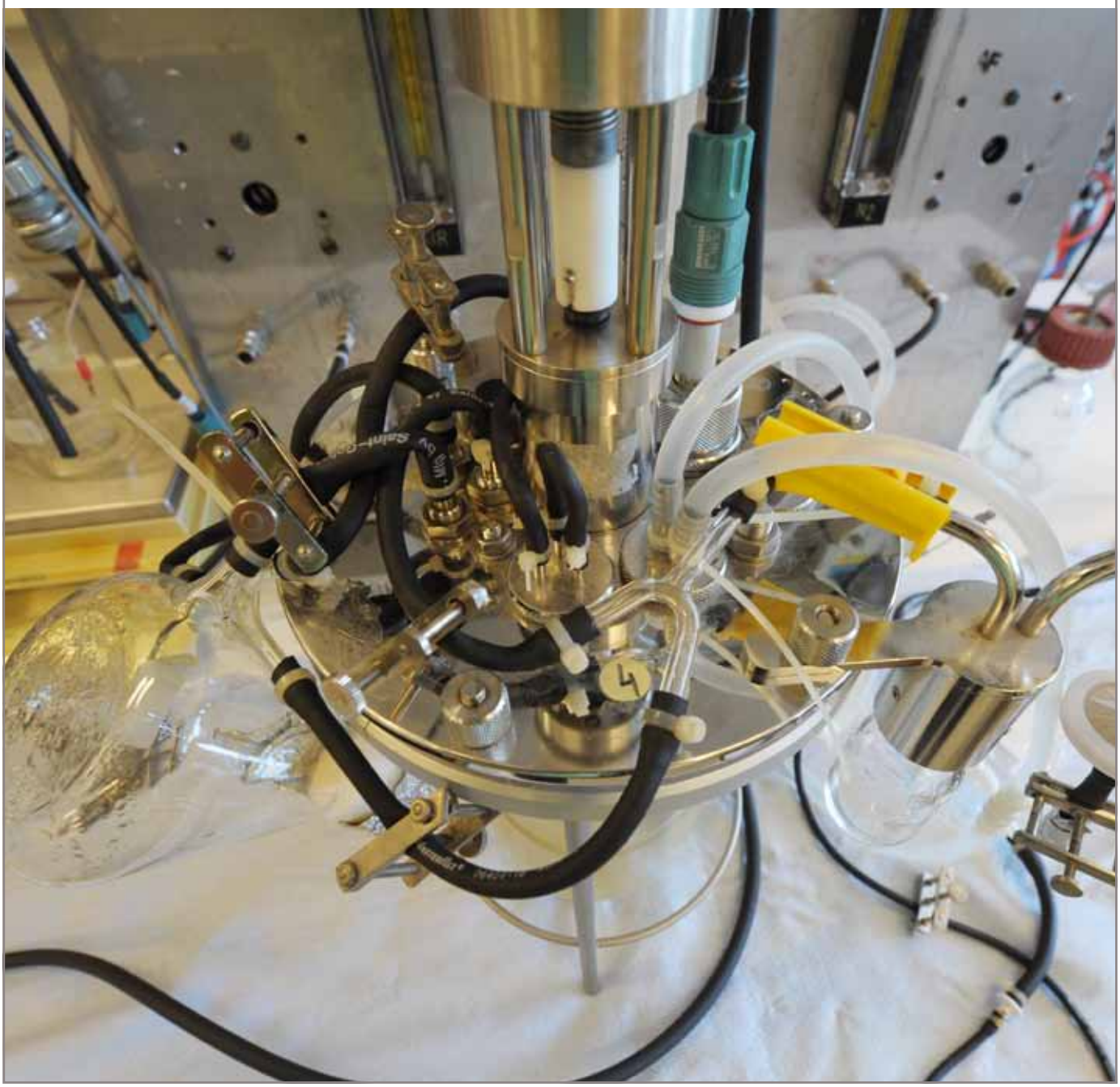
Virtual laboratory

With extensive experience in the field of microbiology, a massive collection of intestinal microbiota samples and an advanced chip methodology to analyse these samples quickly (the so called HITChip), the Laboratory for Microbiology is in a unique global position. Over 5000 intestinal samples have now been analyses in world-wide collaborations resulting in data present in a virtual laboratory in cyberspace. These datasets are now being explored for specific bacteria, enterotypes or other clusters of intestinal microbes that are contribute to our health. The approach taken is generic: from descriptions to understanding and then to predictions and applications; for example in bacterial treatments or transplantations.

Willem de Vos - *willem.devos@wur.nl*

Biochemicals are the building blocks of biobased materials

We are turning basic chemicals green



Is it possible to make car parts from wheat or corn? 'Yes, certainly,' says Jacco van Haveren, Programme Manager Biobased chemicals, Food & Biobased Research. 'We are working on substituting petroleum-based chemicals with biomass chemicals. These green chemicals form the building blocks of biobased materials such as paints, solvents, medicines and glue. But we also use them to make parts for yachts, cars and computers.

There is enough biomass in the world to meet the demanded volumes

Most of the chemicals originate from natural carbohydrate such as sugars, starch and cellulose, but also vegetable oils, lignin and proteins. 'For this purpose we use modern means such as biotechnology, as well as more chemical technologies similar to those currently used for making chemicals out of petroleum.'

Opportunities for industry

Whereas the demand ten years ago was mainly for the production of biodegradable products, today there is a need for biobased products with a longer lifespan. 'We are able to modify the structure of the natural raw materials in such a way that components don't fall off your car before their time and the paint stays on your house for more than ten years,' continues Van Haveren. 'Now that the technology is available, it is up to the industry to start using it. While biochemicals are a little more expensive than traditional chemicals as they are made in smaller quantities, this is set to change. Companies are showing increasing interest in our technology.'

More economically attractive

One market-ready product already created by Wageningen UR is a non-toxic plasticiser. 'We have also developed a chemical for DIY paints, glues and coatings. And we're working on reducing production costs by improving production processes for those biochemicals already on the market. There is enough biomass in the world to meet the required volumes. Once we have developed the envisioned technologies, only 2-3% of all biomass will need to be used for chemicals and materials. Although this won't require a tightening of our belts, we do need to make production more effective in order to enhance the economic attractions of their use.'

Jacco van Haveren - *jacco.vanhaveren@wur.nl*

Perfect micro-constructions

Research into the smallest elements in materials

Although colloid particles are between one and ten thousand times larger than the average atom, they often still display the same behaviour. Joris Sprakel, Associate Professor: 'The major benefit of colloids is that this behaviour can easily be monitored with a microscope, helping us learn more about how atoms behave in materials.'

The Physical Chemistry and Colloid Science group of Wageningen UR is involved in research into the smallest elements in materials, including colloids. Joris Sprakel is carrying out a study into the melting of crystals, among other things. 'Since the start of the previous century, scientists have developed various theories about the physical mechanisms which occur during the melting process. What exactly was happening remained unclear, however.'

The art is to get to know the tricks used by the proteins

Collective movement

Sprakel decided not to study the melting of colloid system in the usual way, namely by increasing the temperature. Instead he reduced the particle concentration. His research showed that the two most common theories, which had always been seen as conflicting, both partially explain how crystals transform into liquid. 'The most important discovery was that the crystals melt from the inside out, and that this is the result of a collective movement of the colloid atoms. It is as if they cooperate in order to liquefy.'

Lego blocks

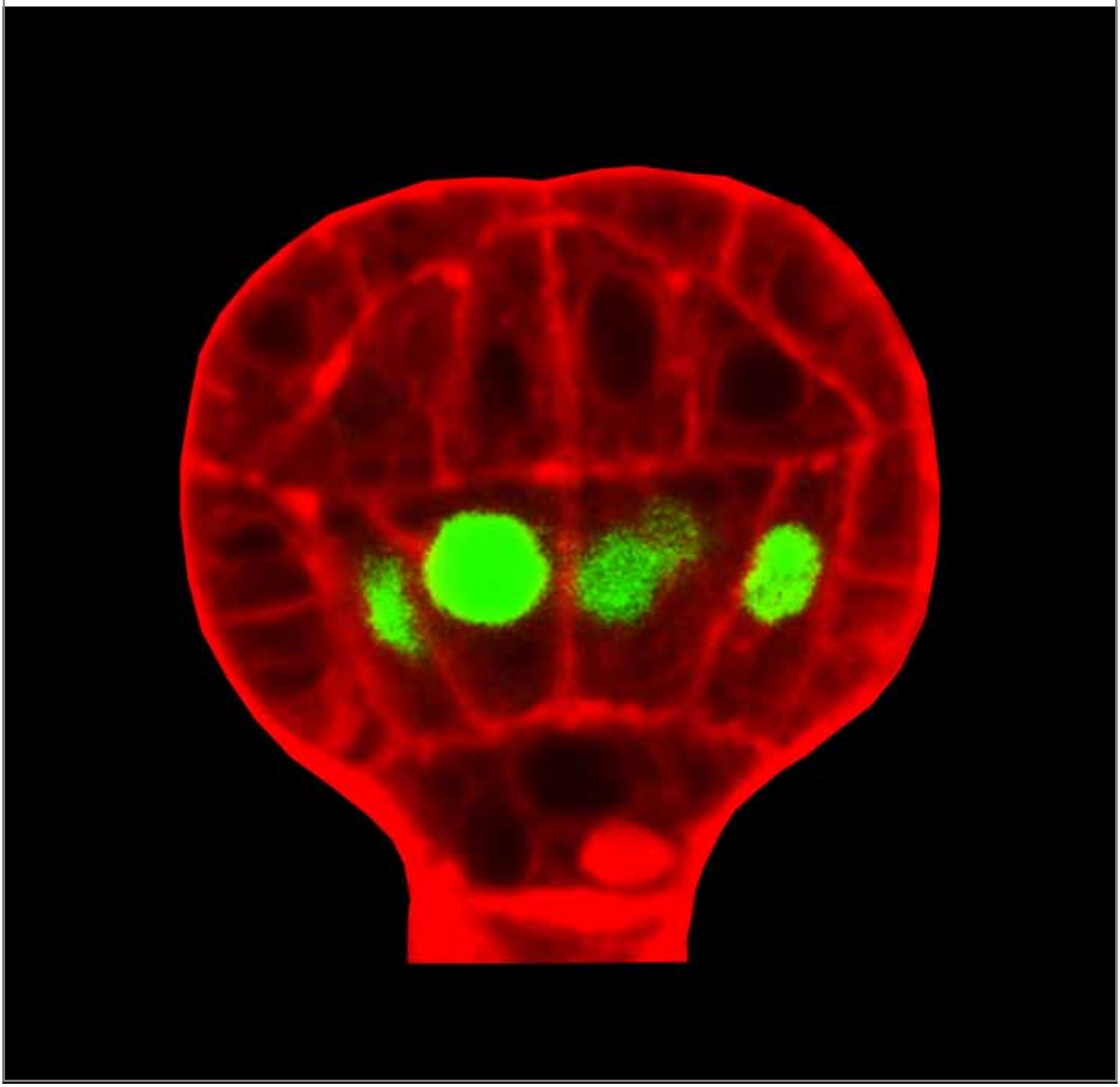
Another study into colloids in which Sprakel is involved is intended to simulate how cells seemingly automatically form the perfect protein constructions. 'A cell consists of a 'soup' of proteins. You could see these proteins as Lego blocks that form constructions. The amazing thing is that these constructions are formed automatically, and that the process is always successful: Every protein ends up in the right place. I want to know what lies at the basis of this self-assembly process.'

Sprakel and his colleagues are also performing tests with synthetic colloids that have been given a dose of small protein fragments, peptides, on their surface. 'We have removed all the other complex segments of the protein and replaced it with plastic particles that serve as peptide carriers. The protein uses these peptides to identify other proteins.' The experiments are intended to test the hypothesis that time is the decisive factor – that things go wrong when the identification process is too fast. Sprakel: 'The hypothesis is that a protein continues its search when it realises it hasn't found the right partner. Eventually the protein aims to be in the right place with the right partner.' The art is to get to know the tricks used by the proteins. 'Then we will be able to use the self-assembly process of proteins to build better materials.

Joris Sprakel - *joris.sprakel@wur.nl*

Biochemistry

Proteins that control stem cells



How do embryonic cells develop into specialised cells and which biochemical processes are controlling this? Dolf Weijers, Professor of Biochemistry of Plant Development, is trying to answer these questions by studying embryos in plant seeds where stem cells originate.

The plant embryo develops from a single cell to a cluster of around 50 cells. And then something interesting happens, says Weijers. 'Some of these cells change their identity and become stem cells. Those stem cells then grow to become the dividing tissue of the plant. The fascinating aspect is that this *meristem*, which is only produced once, produces an entire plant and is active for many years. This is what separates plants from animals: animals only produce organs once.'

We want to find out what it is that makes embryonic cells so unique that they develop into a stem cell

Prestigious grant

Last year Weijers was awarded a prestigious grant from the European Research Council. He is using the 1.5 million euros to carry out advanced research into plant stem cells together with his colleagues at the Laboratory of Biochemistry. 'When a stem cell divides into two cells, one of them becomes a cell of a leaf, stem or flower. The other continues to be a stem cell, which allows the plant to keep growing. We want to find out what it is that makes embryonic cells so unique that they develop into a stem cell. And then we want to determine what should change within a cell for it to continue as a stem cell instead of developing into a specialised cell of, for example, a stem. What biochemical processes take place into these developing cells?'

Organiser cell

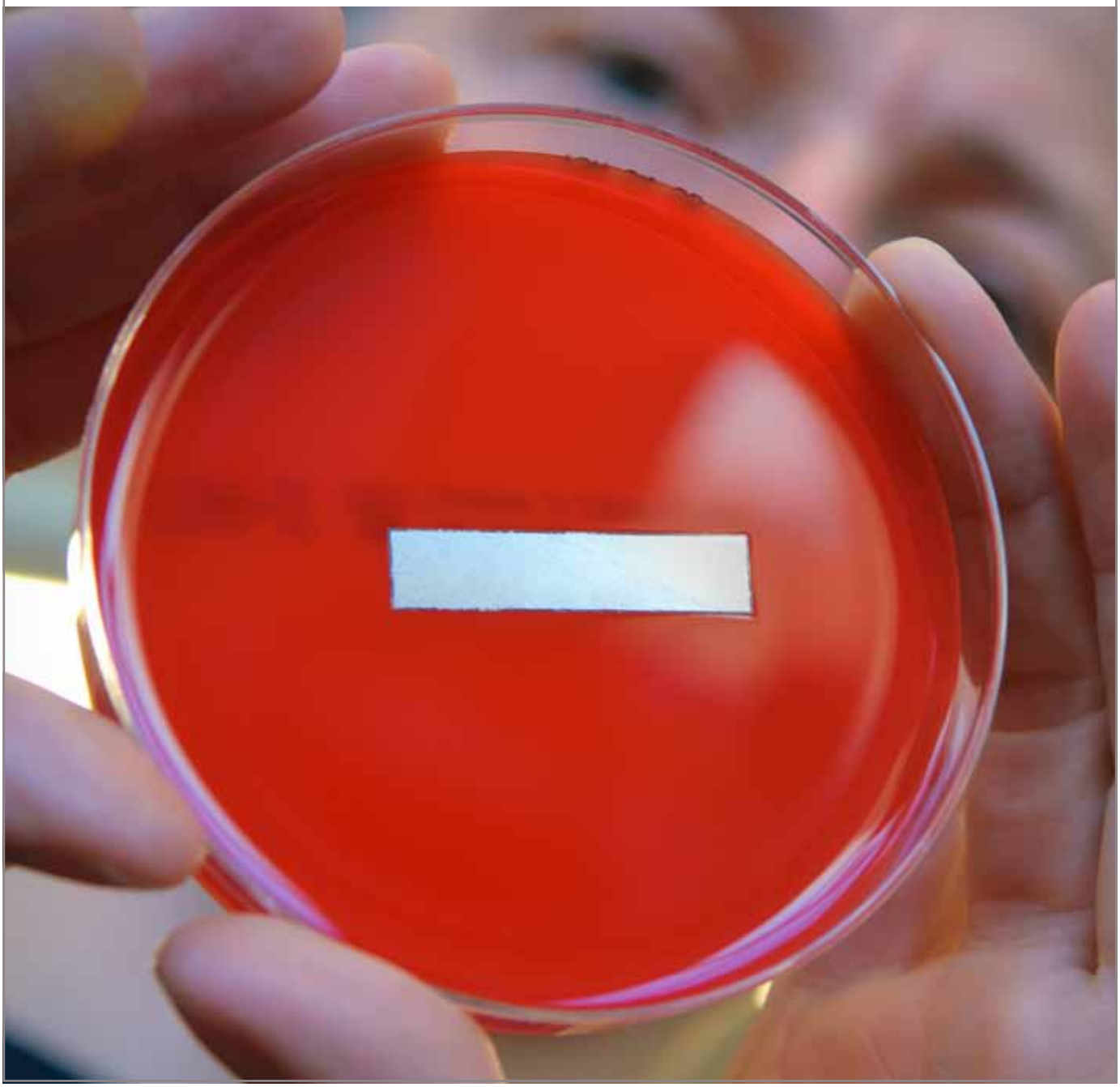
The research zooms in on the role of the mysterious *organiser cell*, which is always located directly beside the stem cell in the meristem. Weijers: 'Organiser cells ensure that the cells beside them remain stem cells. We know that the plant hormone *auxin* contributes to embryonic plant development. We also know that, influenced by *auxin*, the *monopteros* protein is responsible for a 'travelling' transcription factor. This transcription factor, TMO7, is then transported to a cell, which becomes the only cell in the meristem to develop into an organiser cell. We want to find out why the transcription factor is only transported to that specific cell.'

Although, as a fundamental scientist, Weijers is not directly participating in applied research, he is aware that the agricultural sector is extremely interested in the type of research in which he is involved. 'Once we understand how stem cells make a plant grow and which molecules organise the development, we'll have the knowledge required to influence the growth of plants. Examples include improving crop characteristics or increasing their yield.'

Dolf Weijers - *dolf.weijers@wur.nl*

‘Almost nothing’

Looking at layers of one billionth of a metre



The layers are one molecule in thickness, attached to strips of porous aluminium oxide. 'Almost nothing, you could say,' comments Han Zuilhof, Professor of Organic Chemistry. Nonetheless, one strip of several square centimetres in thickness contains several thousand microscopically small Petri dishes, making it possible to identify bacteria much faster.

The research revolves around a subsector of organic chemistry and one of the projects is carried out in cooperation with the Microbiology chair group of Wageningen UR. An advanced electron spectroscope makes it possible to see which molecules form such a thin layer of one molecule (which equals two nanometres) on a substrate of aluminium oxide. In comparison: A pinhead is approximately one million nanometres thick.

To develop a coating for milk that prevents proteins from binding

Zuilhof and his colleagues are studying whether the top layer can be adapted in such a way that it captures some bacteria but not others. The electron spectroscope then provides very fast and accurate test results. The social relevance of this is substantial, according to Zuilhof. 'It can make a difference whether the results from a test for sexually transmitted diseases are available within five days, or a few hours.'
The research is part of NanoNextNL, a large research programme with a budget of 250 million euros of which half is provided by the Dutch government, and half by private parties. Zuilhof's chair group is proportionately the largest group within the programme.

Membranes

Another study with which the Organic Chemistry chair group of Wageningen UR is involved focuses on the possible modification of membranes. Membranes are thin plates with precisely defined holes that allow or prevent substances from passing through. As an example, Zuilhof and his colleagues worked with the Food Process Engineering chair group to develop a coating for milk that prevents proteins from binding. Previously, these protein compounds plugged the holes in the membrane as a result of which it quickly became polluted. Constantly searching for innovative new products, the food industry is extremely interested in this type of application.

CO_2 capturing

A third project Zuilhof and his colleagues are working on takes place within the international research programme CATO-2, which studies the possibilities of CO_2 capture, transport and storage. The subproject is looking at the chemical aspects of capturing CO_2, studying a new power plant in the port of Eemshaven in the north of the Netherlands. Wageningen UR is researching which chemical factors should be changed to further improve CO_2 capture in power plants.

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Colophon

Publisher
Wageningen UR
Project management
Wageningen UR, Communication Services
Interviews and text
Shirley Domingus
Jeroen van den Nieuwenhuizen
Translation
Writewell (Andrew Rogers, Akke Pinkster, Damir Avdic)
Graphic design and photoresearch
Wageningen UR, Communication Services
Printing
MediaCenter, Rotterdam
Photography
Wageningen UR, Communication Services (20,52)
Guy Ackermans (21, 30, 34, 49, 58, 63, 64)
Bart de Gouw (40)
Scarlet Haag (61)
Gea Hogeveen (32)
Hoogesteger (50)
Wiegerinck architectuur en stedenbouw, Arnhem (2)

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ISBN 978-94-6173-480-8

Wageningen, September 2012

www.wageningenur.nl