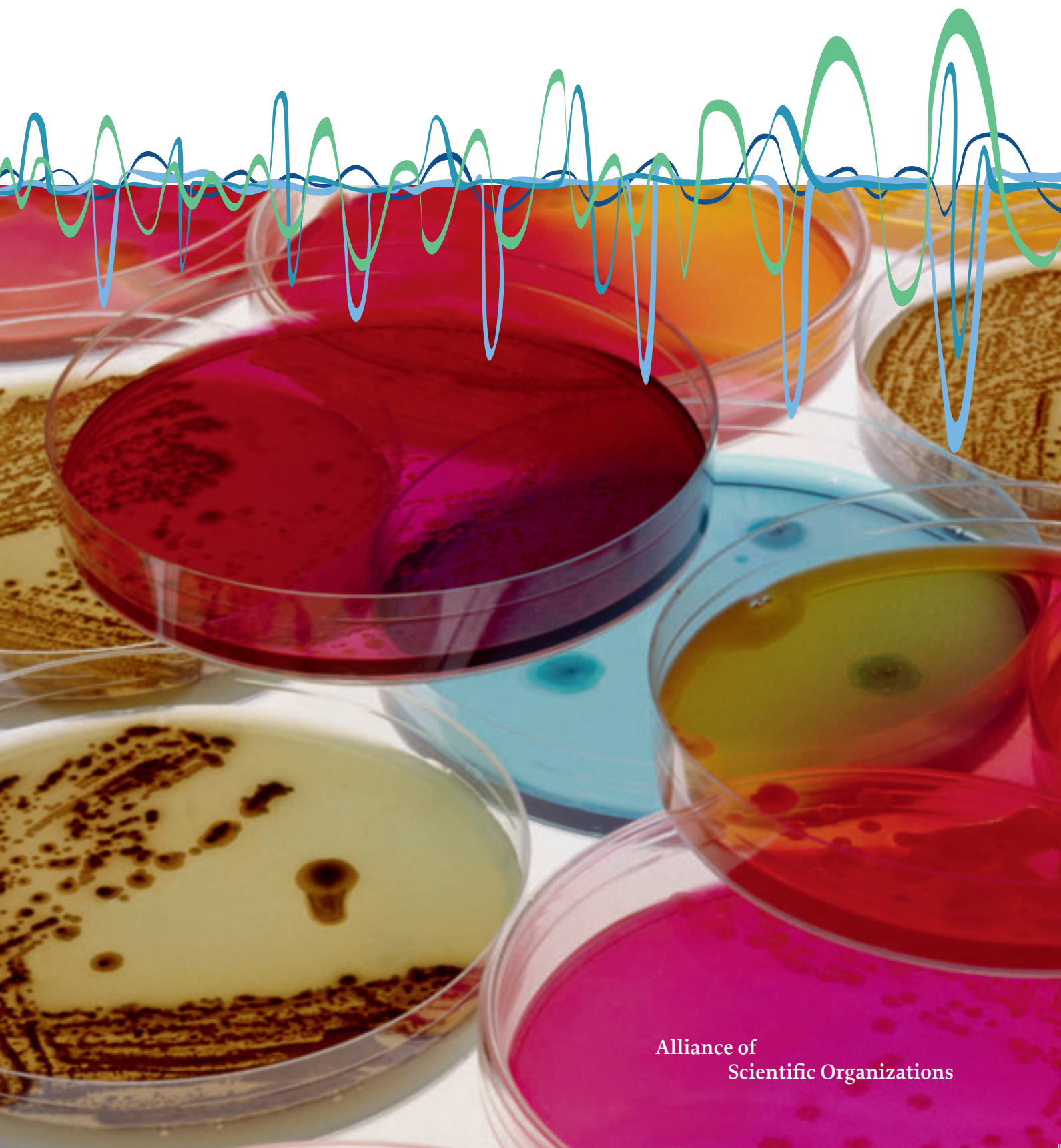


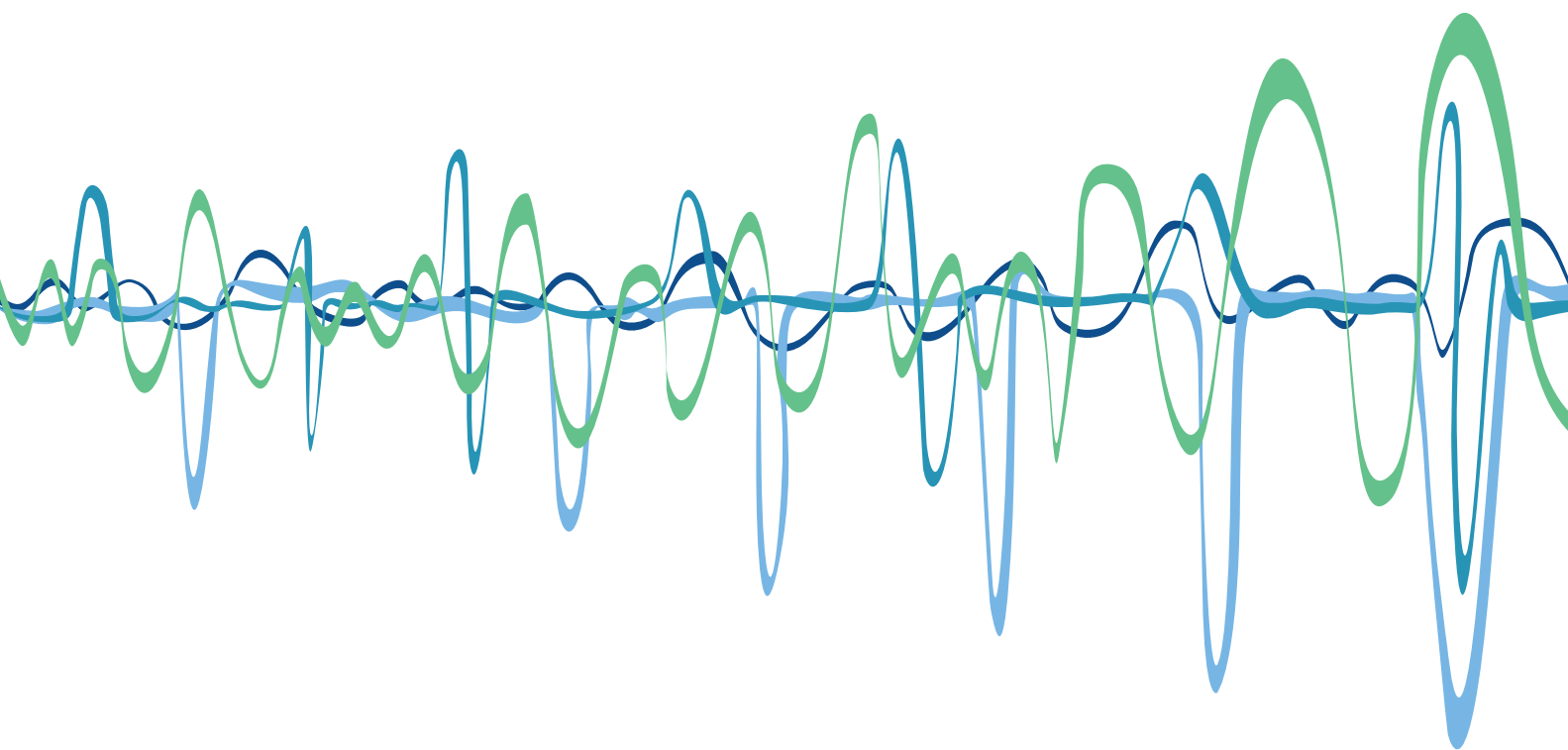
Researching:  
**Health**

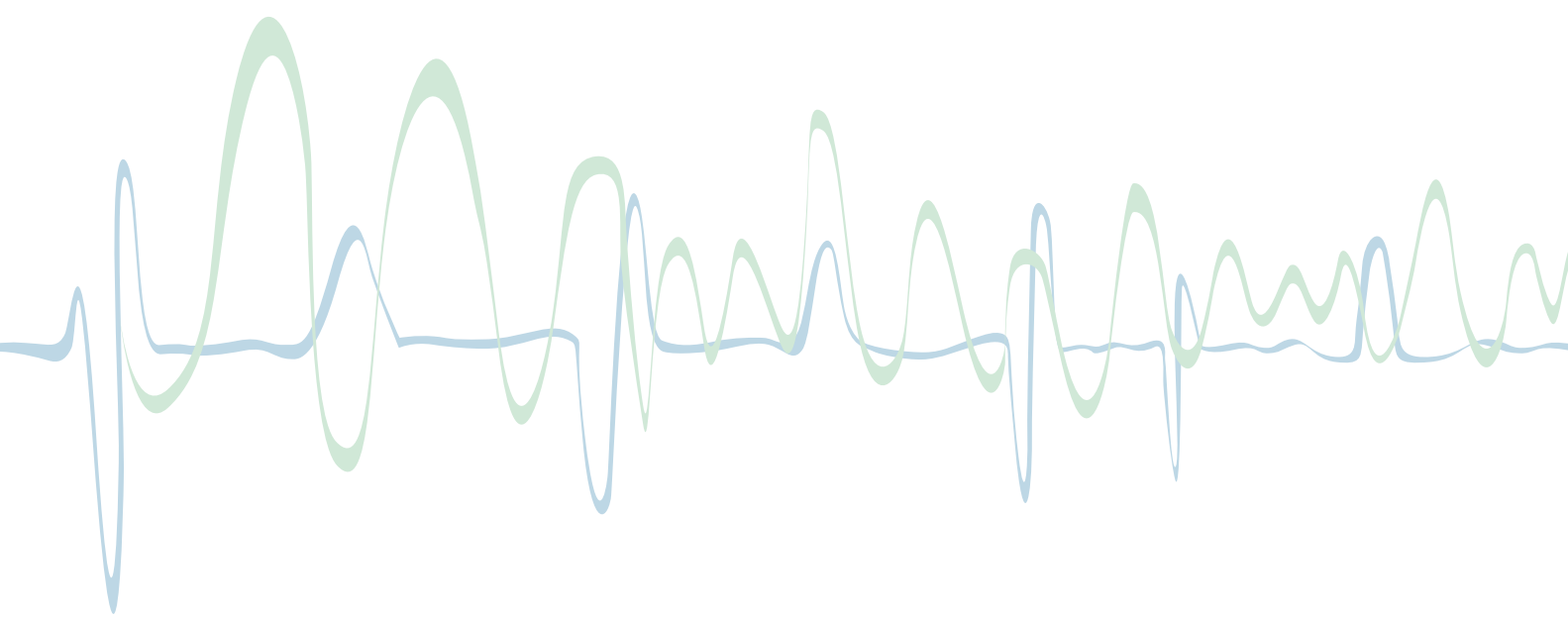


Alliance of  
Scientific Organizations



Researching:  
**Health**







## Message of Greeting

In recent years the processes of innovation have gained significant dynamic force. The “High-Tech Strategy for Germany” has been a major factor in this. Introduced in the last legislative period, it constituted the first national all-embracing concept for the research sector and has led to a new quality of cooperation between the scientific, business and political communities. In developing the High-Tech Strategy further, proven measures will be continued, but new points of emphasis are also being accentuated. The “High-Tech Strategy 2020” focuses on five major areas: climate and energy, health and nutrition, mobility, security, and communication. The aim is to make Germany a leader in the solution of urgent global problems by giving impetus to new technologies and innovations and by pooling the resources of science and industry.

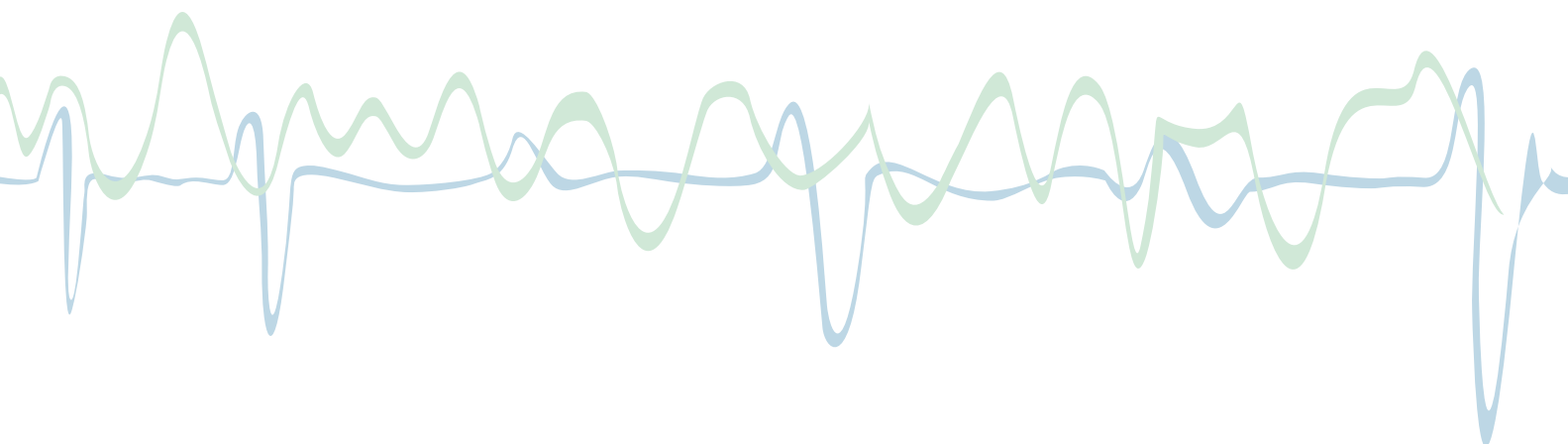
The members of the Alliance of Scientific Organizations have a key role to play in the successful implementation of the High-Tech Strategy. So that science can perform its central task in research and development, in technology transfer and in the innovation process, the federal and state governments have agreed to continue with the Pact for

Research and Innovation, and to support the Excellence Initiative and the Higher Education Pact. Together, these initiatives represent the biggest investment in research, science, innovation and education ever seen in Germany.

The scientific organizations are successfully addressing issues of the future and are advancing into new areas of research. The current series of brochures shows how well German research is placed to deal with the major future challenges. Each brochure is devoted to one of the main subjects identified in the High-Tech Strategy and uses engaging examples to illustrate the work conducted in Germany’s research institutes. With their easy-to-understand descriptions of advanced research, these publications support the broad dialog with the public on the pressing questions of our time.

A handwritten signature in blue ink that reads "Annette Schavan". The signature is fluid and cursive.

Prof. Dr. Annette Schavan, MdB  
German Federal Minister of Education and Research



## Preface



Dear readers,

Hippocrates knew of the benefits of prevention even in his days. He recognized that we should “let food be thy medicine, thy medicine shall be thy food”. In the Western world at least, we have a wide variety of food to choose from. But our physical well-being is not only dependent on what we eat: people who do not take regular exercise, for example, put their health at risk. How well we feel physically is strongly influenced by the choices we make every day between the sofa and the sports field, between organic and fast food. While we can certainly welcome the fact that people are living longer, this poses enormous challenges both for every individual and for medicine in general. If we want to be healthy in our old age, there is a lot we can do to help ourselves. It is particularly important to take a long hard look at our lifestyle if we wish to lower our risk of developing many common diseases.

In order to cope with the demographic changes that are taking place, we must formulate new concepts in research, medical technology, health policy and the labor market. Basic, clinical and pharmaceutical research must converge and work in closer harmony, rather than pursuing separate agendas. The key word is translational medicine: “from bench to bedside and from bedside to bench” – from the laboratory to the patient and from the patient back to the laboratory. New findings in basic research find their way directly into clinical practice and can quickly contribute toward improvements in preventive, diagnostic and therapeutic methods. The reverse is also true: open questions from everyday clinical practice can be specifically dealt with by scientists working in basic research. In this way, researchers, medical staff and above all patients benefit from new findings.

Our quality of health in the future not only stands to benefit from the translational approach to research, but also from advances in medical technology. Modern, low-risk diagnostic and therapeutic methods combined with increasingly accurate imaging techniques enable us to detect diseases at an early stage. The earlier intestinal or breast cancer is diagnosed, for example, the better the chances of recovery. Medical technology is also an important economic factor and in the long term can ease pressure on the health budget. Improved surgical techniques ensure that patients can leave hospital earlier – saving money both for the health system and for the patient.

Another important field in health research is personalized medicine. Until now, risk data for certain diseases have been formulated in a very general way. An individual risk assessment could be based on new insights provided by the field of genetics.

In this brochure, “Researching: Health” by the Alliance of Scientific Organizations, we would like to take you on a journey through the health research being carried out today for the benefit of medical care tomorrow. I hope you will find the journey exciting and enjoyable.

Sincerely,

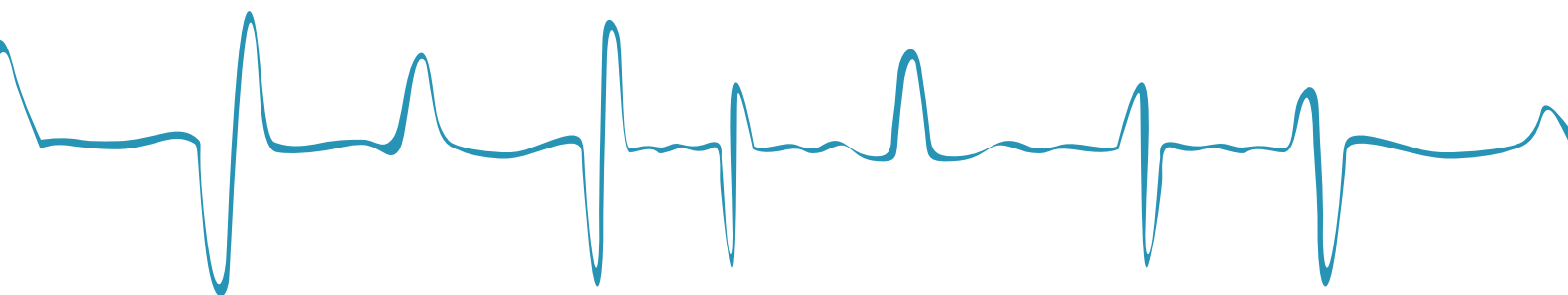
A handwritten signature in blue ink, reading "J. Mlynek".

Jürgen Mlynek  
President of the Helmholtz Association



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## Healthy and independent

One of the most remarkable demographic changes over the last century has been the substantial rise in average life expectancy. But people are not only living longer, they also reach old age in better health. So although we may be challenged by the impact of demographic change, it also offers great opportunities. The influence of polemical attitudes expressed in talk of “war of the generations” or the “ageing society” has diminished into obscurity. The achievements of the welfare state, and the degree of prosperity it has brought to so many, can in principle be sustained with an ageing and diminishing population.





**Older employees are a valuable asset for any company.**

This nevertheless depends on being able to raise the level of employment and increase the productivity of those employed. There are undoubtedly reserves in the German labor market amongst those over 55, amongst women and migrants. Tapping these reserves calls for adjustments in national economic policies, in individual companies, in education and training and in the healthcare system. The same applies to aspects of the social system such as the support given to families.

Ageing as we know and experience it today is only a snapshot. Human development and ageing are not determined by the laws of nature, but are instead the result of continuous interaction between biology and culture. Even in its biological components (key word: epigenetics), ageing can be changed – within biological limits – in response to influences exerted by society and the individual. Our idea of ageing and the roles we invariably attach to people of a certain age are nevertheless still characterized by the traditional view of ageing. They evolved at a time when our life expectancy,



Gerontology

### **Reclaimed years**

People are increasingly living longer and are also staying in better physical and mental health in their old age. "Old" is no longer synonymous with "infirm". The traditional picture of an ageing society is all-too-often associated with a loss of innovation, productivity and quality of life and an increasing burden on the social system. But this need not be the case. The Joint Academy Initiative on "Ageing in Germany" by the German National Academy of Sciences Leopoldina and by acatech – the German National Academy of Science and Engineering – emphasizes the opportunities which demographic change can offer for all of us, both at the level of the individual and for society as a whole. If we wish to realize these opportunities, we must make changes in the world of work and in the education system, in the home environment and in the communal infrastructure, and in our attitude to our bodies and our health.

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Gerontology

### **Staying mentally fit in old age**

Older people today are more capable in many areas than in years gone by and have also an increased life-time expectation. Adulthood thus provides us with a scope for development which should be defined and utilized. Scientists at the Max Planck Institute for Human Development are studying the causes of favorable and unfavorable courses of ageing. Physical, social and emotional factors play an important role here. The researchers are analyzing how perception, motor function, intellect and memory change over the course of a person's life and are also analyzing the effectiveness of measures for increasing performance in these areas. This enables them to make recommendations about how older people can stay as mentally fit as possible.

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## 1 Research for a better quality of life in old age



Lifelong learning enables us to keep pace with modern society.

the quality of life in old age and the distribution of roles over a person's lifetime were quite different than today.

How can the required reserves be activated? The future viability of a society with an ageing population depends on its willingness to change. The academy's research has identified important steps toward changing outdated systems in the world of education, the labor market and the national economy, in wider regions and local communities, in families, civil society and government, in the minds of the people and in everyday

practice. If demographic change is to become a demographic opportunity, it is clear that this change must go hand in hand with further changes at the institutional, social and cultural level.

It is worth making clear from the start that an extended working life does not simply mean increasing the number of years people conventionally work in Germany today. It is more a matter of changing the conventional sequence of education, work, and retirement during the course of our lives. It is about making the necessary modifications to structures in various areas of life.



### Neurodegenerative diseases **Dementia research**

The risk of developing neurodegenerative diseases increases with age. The cause of memory impairments occurring in patients with Alzheimer's disease seems to be the loss of neural connections, but this also appears to be part of the ageing process. Dr. Daniele Bano is searching for genes and physiological mechanisms which influence the ageing process and is attempting in this way to explain why one person will develop Alzheimer's disease and another will not. He is using the simple model organism, the nematode, to study gene variants which make some worms live longer. The genes appear to be influenced by external factors. Dr. Bano's goal is to understand the mechanisms of neurodegeneration and to identify factors which link ageing and neurodegeneration.

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### Gerontology **Assistance systems for the home**

"Ambient Assisted Living" (AAL) is the application of "ambient intelligent" systems for personalized assistance and support. In an environment filled with information and communication technology, the components of intelligent environments are able to interact in a context-specific, coordinated, and automatic manner with the person using them. Together with "personal health" concepts, AAL makes innovative forms of healthcare and social care possible. AAL contributes toward solving the resource and cost problems in the health and social sectors which are the result of demographic change in industrialized nations.

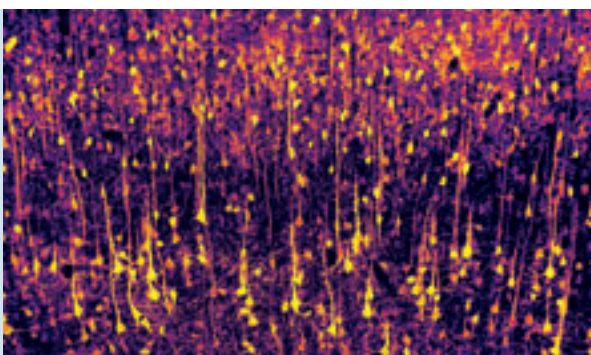
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**Demographic change will require new lifestyle patterns.**

Demographic change is forcing a shift of focus, leading us away from a highly-productive middle age and toward having an active lifestyle throughout our adult life and in old age. Pursuing further training and making time for the family during middle age whilst encouraging more active participation of older age groups in the labor market and social institutions is at the same time both the major challenge and the greatest opportunity of demographic change for the individual, the labor market and society as a whole.

Whether these goals are achieved and to what extent they are successful depends on the willingness of all those in society to take action. It is clear that demographic change is increasing the existing pressure for change which is already on the individual and on the culture, on society and on government. It is essential to use this pressure as a driving force for the necessary changes. Demographic ageing will then contribute toward the social dynamics, becoming a demographic opportunity.



Gerontology

### **Innovative tracer using the example of thallium**

Every day, thousands of neurons die without us noticing. As a result of a stroke or over the course of neurodegenerative diseases, however, massive cell death in the brain leads to a prolonged or even permanent decline in mental health. In order to enable early therapeutic intervention, it is important to quickly and reliably identify regions in which the electrical communication between neurons is breaking down, before the cells die. But how can electrically inactive nerve cells be distinguished from those which are electrically active? Neuroscientists in Magdeburg are developing an innovative tracer which, after being chemically packaged in lipid-soluble complexes, crosses the blood-brain barrier and is absorbed only by healthy and active cells.

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Gerontology

### **Work and old age**

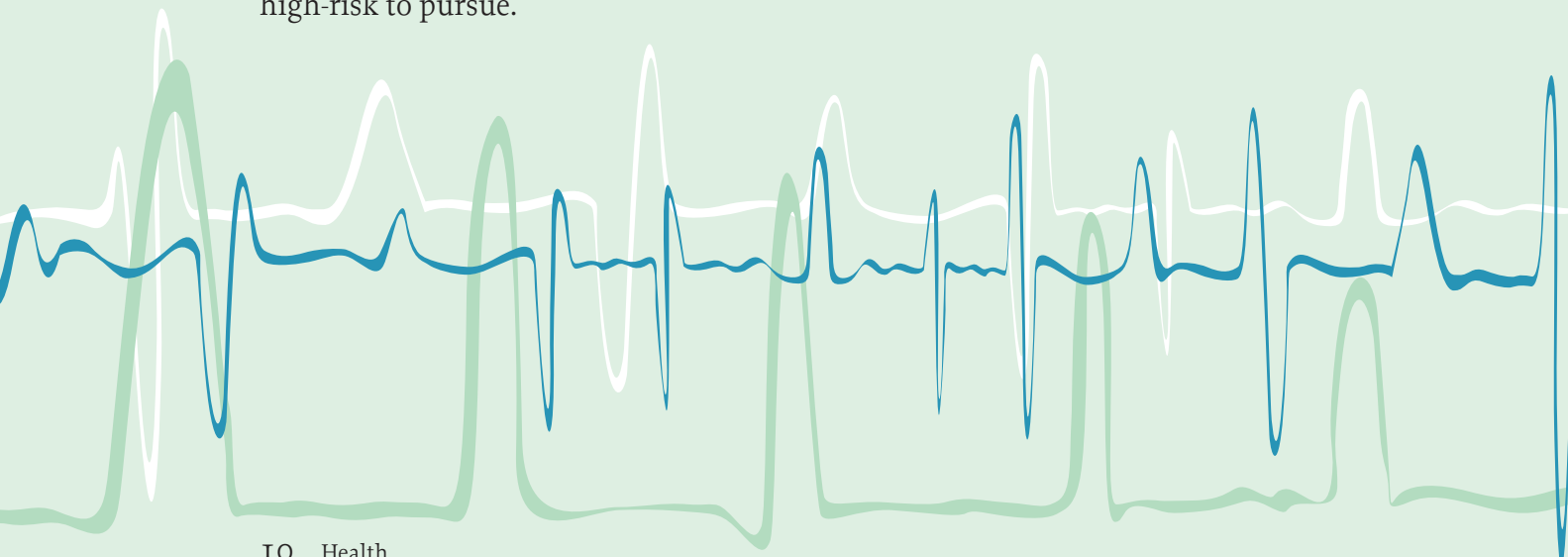
The workforce is getting older all the time, while at the same time people are increasingly taking early retirement. The result is a shortage of skilled labor and increased strain on social security systems. These challenges are being addressed in an interdisciplinary approach by the research initiative "Elderly workers" at the Leibniz Research Centre for Working Environment and Human Factors. Scientists are analyzing the cognitive development and the performance of people in employment and are using this information to make specific adjustments to work systems. They are developing training for older workers and managers as well as training for individuals with declining mental function. This makes it possible to identify ways in which older people can participate in the world of work, both long-term and at a high level.

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## From drug development to patient care

Until a few years ago, basic, clinical and pharmaceutical research were separate disciplines with little interaction. Any contact and exchange of ideas between disciplines was rare. The methods, self-image and goals of the researchers were – and are – very different: gaining knowledge in one instance, as opposed to process or product optimization elsewhere. Results from basic research found their way into clinical use – and thus ultimately to the patient – only very slowly or often not at all. Many developments only reached a stage in the academic environment which the pharmaceutical industry still considered to be too high-risk to pursue.





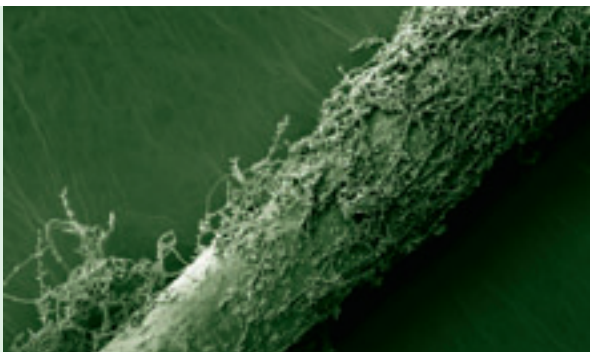
It can take up to ten years to develop a new drug.

## Development of therapeutic and preventive vaccines

While findings from basic research often lead to fundamental shifts away from previous approaches, which are then put into practice rather slowly and gradually, new findings from applied research can quickly lead to more major changes. This happens rarely, however – and there are many different reasons for this: it is often not enough for a promising invention to exist. Instead, there must already be sufficient information for the chances of implementation to be estimated. This

is the only way to find public or private sponsors who are willing to finance further development. In addition, issues such as those relating to intellectual property must be clarified in order for profits to be realized at a later point in time.

Efficient development of new drugs, therapies and vaccines can only be guaranteed by close collaboration between multidisciplinary partners. The key word



Infection research

### From natural substance to pharmaceutical

Pathogens long thought to be under control are becoming resistant to current antibiotics. In addition to this, there are new emerging pathogens, which cause serious and often fatal infections. People with weakened immune systems (e.g. following organ transplantation) often suffer from fungal infections which are frequently untreatable. Researchers at the Leibniz Institute for Natural Product Research and Infection Biology are isolating natural substances from newly discovered microorganisms and studying their biological functions: functions which have been optimized over the course of evolution. Biologists, biotechnologists, pharmacists and chemists are working in an interdisciplinary manner to develop new drug candidates from these natural products. In doing so, they contribute to the future treatment of dangerous infectious diseases.

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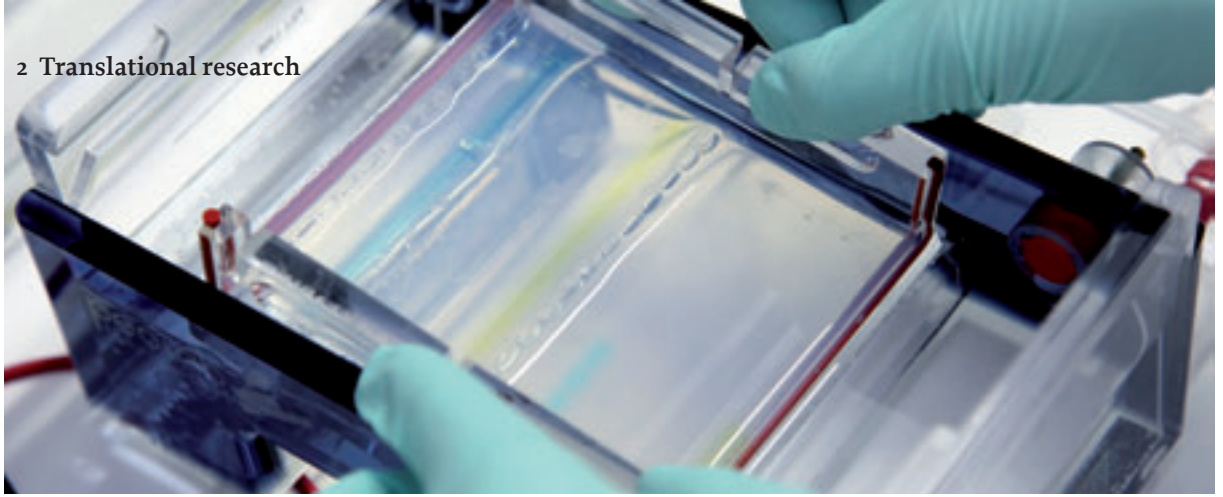
Infection research

### The green biofactory in the fight against AIDS and malaria

AIDS and malaria are among the world's most dangerous infectious diseases, and new drugs are urgently needed in sufficient quantities for their diagnosis and treatment. Researchers at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME have successfully developed an innovative plant-growing platform for the safe and economical mass production of suitable biopharmaceuticals. They produced a neutralizing anti-HIV antibody in tobacco plants under strict pharmaceutical guidelines in a feasibility study and have pioneered clinical evaluation in the EU. Currently, the researchers are developing new malaria vaccines to be produced in the future in an automated plant-growing facility.

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## 2 Translational research



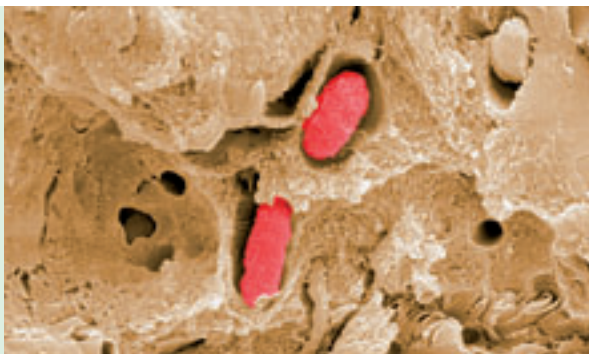
Collaboration between research and practice is the starting point for translational research.

here is “translation”. The aim of translational research is a continuous exchange between different areas of research, which accelerates the processing of results to produce an application. Universities, research institutions, hospitals and the pharmaceutical industry are collaborating on joint projects.

The idea behind translational research is “from bench to bedside and from bedside to bench”, from the laboratory to the patient and back to the laboratory. Basic research provides the potential starting points for new

drugs or therapies in the laboratory. These results are developed further in clinical research and are tested in early clinical trials for safety and, in the next step, for effectiveness. The clinical trials generally raise new questions, which the basic researchers and clinical researchers then address again immediately.

In the ideal scenario, at the end of this process a new medication is developed and the results are implemented in routine clinical practice.

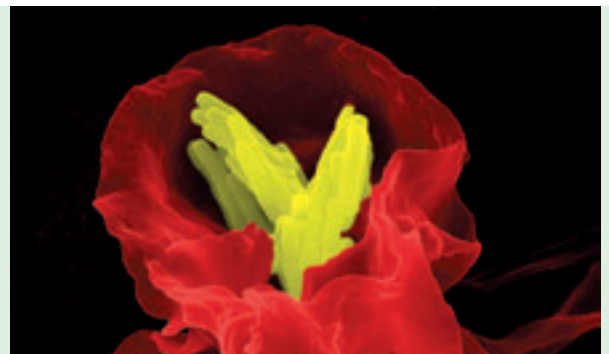


Infection research

### Salmonella in the fight against cancer

Salmonella has a bad image: in summer, it crops up in connection with contaminated food. Salmonella don't just make people ill, though – in the future, it could play a crucial role in cancer therapy. The bacteria migrate selectively into tumors and could help to destroy them. Researchers from the Helmholtz Centre for Infection Research are studying how salmonella enters tumors. They have found that an immune system messenger opens the door for the pathogens. It makes the blood vessels in cancerous tissue permeable, enabling the bacteria to invade and colonize the tumor. The researchers' aim is to modify the salmonella such that it releases an active substance into the tissue of the tumor without affecting the surrounding healthy tissue.

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Infection research

### A new vaccine for the white plague

Sometimes progress is slow: the tuberculosis vaccine used today has already been in use for 80 years, and more effective protection has never been needed more urgently. The out-dated vaccine is ineffective against resistant strains of the bacteria, which are on the increase globally. Scientists at the Max Planck Institute for Infection Biology are working on the development of a new tuberculosis vaccine. The researchers have genetically modified the weakened form of the bacteria contained in the vaccine so that the immune system can recognize it more easily. The vaccine candidate thus induces a stronger response by the immune system and should therefore provide greater protection against tuberculosis. It is currently being tested in clinical trials.

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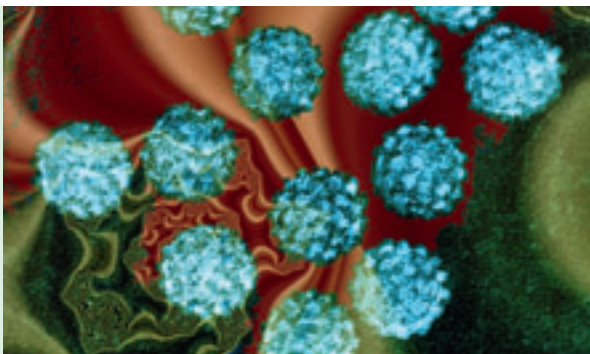
Many people suffer from diabetes without knowing it.

## Widespread and infectious diseases

Despite major medical advances in recent years, many widespread diseases such as cancer, diabetes, chronic inflammation and infections to this day still cannot be adequately treated. This is particularly true of infectious diseases, because pathogens are increasingly becoming resistant to the vaccines and drugs available. This is due to the enormous adaptability of pathogens, but also to the often excessive and improper use of anti-

biotics, such as in animal husbandry. In addition, new infectious diseases are emerging all the time and are able to spread rapidly on the tide of globalization.

It is therefore vital to push ahead with the development of new treatments and vaccines for widespread and infectious diseases. Interdisciplinary collaboration can open up completely new treatments. For example,

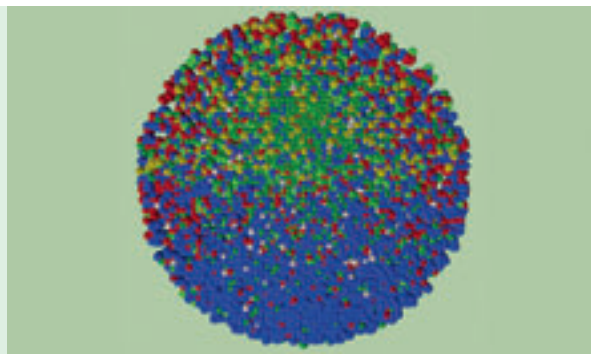


Cancer research

### Vaccines against cervical cancer

In 2008, Harald zur Hausen was awarded the Nobel Prize in Medicine for his discovery that some forms of the human papillomavirus (HPV) cause cervical cancer. He made it possible for vaccines to be developed which can protect against cervical cancer. The vaccines are very costly and labor-intensive to produce and also require constant cooling. This makes them so expensive that they are not affordable in Third World countries, where they are urgently needed. The Helmholtz researchers led by Lutz Gissmann are therefore working on the "second generation" of vaccines: they are easier to produce and can be stored unrefrigerated. They are also expected to be effective against cells which are already infected. The new vaccines are therefore able not only to prevent cancer but also to treat early forms of the disease.

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Quantitative methods

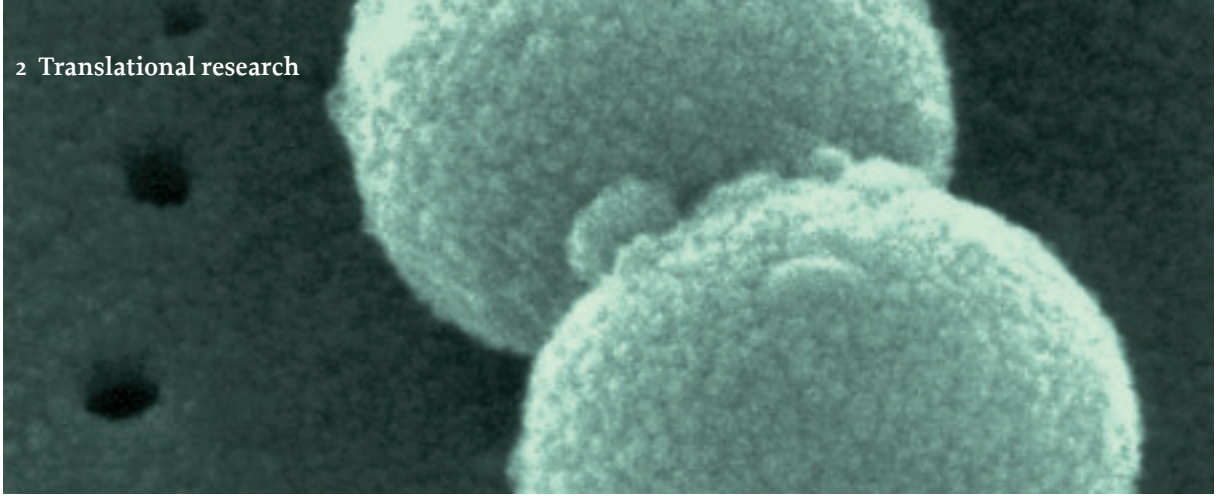
### Systems biology for more effective treatment

With systems biology, a new method has become established in the medical research community. This method has turned the study of biological systems into a quantitative science. Using methods derived from physics, biological systems are broken down into their fundamental elements and analyzed on the computer. Hypotheses and predictions developed on the computer can be proved or disproved using specific experiments. Using quantitative models such as these, the response of patients to specific drugs can be optimized by computer simulation. Even though "personalized treatment" of patients is still a long way off, systems biology is a big step in that direction.

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## 2 Translational research

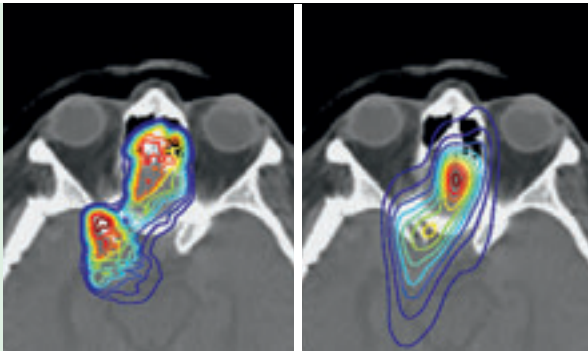
Microorganisms can cause infectious diseases.



### Lung and allergy research

scientists can use methods from molecular biology to study the causes and effects of diseases and infections and use computer models to test which reactions are triggered in the human body by drugs and vaccines.

In translational medicine for the development of new diagnostic and therapeutic products and procedures, success is the result of the mutually fruitful research carried out in biomedical laboratories and the clinical environment. Various biopsies taken from the patient – representing the progression of the disease in vivo – are analyzed using the latest bioanalytical and molecular genetic technologies developed in the research laboratory, in order to gain insights into the pathogenesis and find possible therapeutic approaches.



Cancer research

#### Nuclear physics used to combat cancer

Nuclear physicists often experiment on giant particle accelerators and develop sensitive detection devices in order to be able to measure the exotic states produced by particle collisions. This is also of benefit to medical diagnostics: faster and smaller detectors are driving forward the development of new and improved scanners. Physicists at the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) are also making use of nuclear physics processes that take place in the bodies of cancer patients during ion therapy. The in-beam PET method which they have developed visualizes the interaction of the ion beams with the tissue during treatment. This method ensures that the ion beams only destroy the cancerous cells, leaving the healthy tissue largely unharmed.

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Lung research

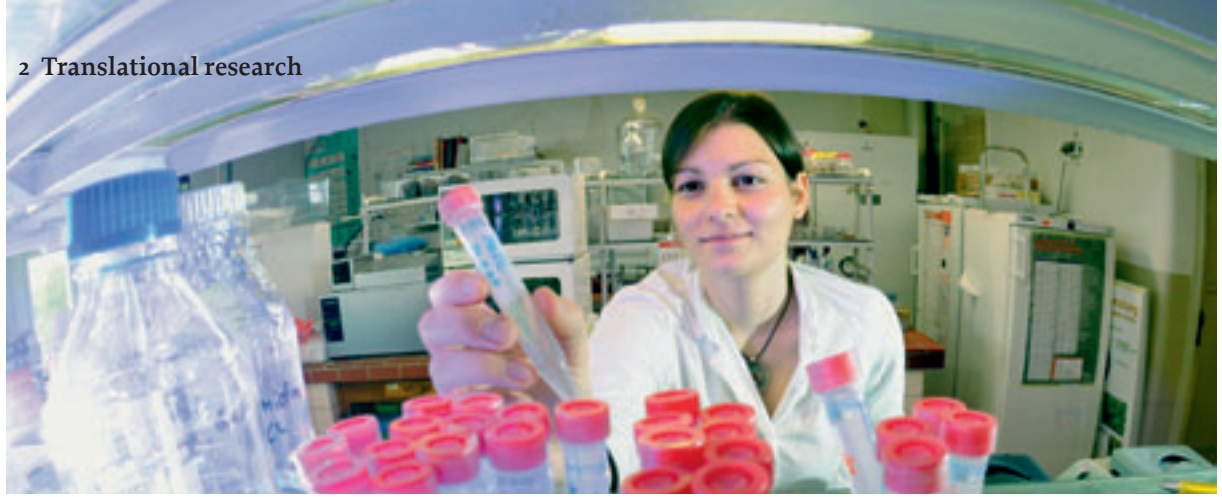
#### Specialized cooperation and translation

Respiratory diseases such as chronic obstructive pulmonary disease (COPD), asthma and hay fever are among the most widespread diseases. Research into these diseases and the development of therapeutic applications for patients are the aims of two new research centers. The Comprehensive Pneumology Center (CPC), founded by the Helmholtz Zentrum München together with university and clinical partners, is working in a close exchange between basic and clinical research. Together with its research and pharmaceutical partners, the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM has established all the necessary steps for the development of new medications under the umbrella of a new translation center. This also includes conducting stage I and II clinical trials.

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A disease is considered rare if less than 5 people in 10,000 suffer from it.

### Rare diseases

Rare diseases affect less than 5 in 10,000 people. It is therefore not just the individual disease which is rare but also the specific treatment options for the affected patients. For this reason we also talk of orphan diseases and neglected diseases. Patients with rare diseases often report having had a long and seemingly directionless struggle to find a diagnosis. For many patients with rare diseases, there is no available treatment, or there are only limited treatment options.

There are currently around 5,000 to 7,000 rare diseases known to medical science. This uncertainty is explained by the fact that many rare diseases are not yet included in the International Classification of Diseases. Most rare diseases are genetic. Although each individual disease taken by itself is very rare, when viewed as a whole rare diseases are of great socio-economic significance, since current estimates suggest that approximately 4 million people in Germany suffer from a rare disease.

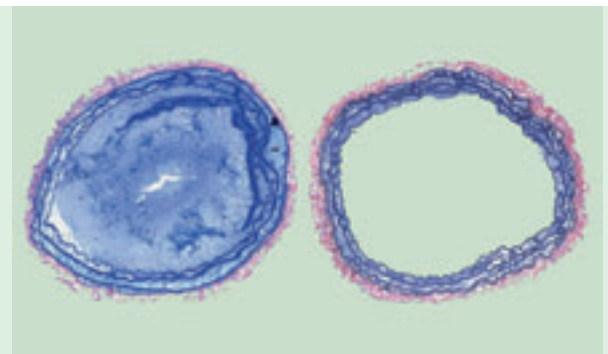


Rare diseases

#### **An opportunity for new therapies**

Knowledge of the genetic causes of diseases not only opens up the possibility of an exact diagnosis, but it also forms the basis for developing innovative therapeutic strategies. Research into rare diseases, which are often caused by a single genetic mutation, is pointing the way in this context. For example, the first successful gene therapy studies were performed on patients with monogenic diseases. The findings open up unforeseen new horizons for a deeper understanding of the development and function of our organ systems. The German Federal Ministry of Education and Research (BMBF) supports 16 interdisciplinary research networks which research the genetic causes of rare diseases and develop groundbreaking therapeutic options.

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Rare diseases

#### **anchors for immune cells**

In order for white blood cells to be able to reach pathogens in the tissue surrounding the blood vessels, the immune cells must migrate to the blood vessel walls and pass through them. Otherwise, serious infections may occur as a result, as in the case of patients with the rare hereditary disease leukocyte adhesion deficiency III. Researchers at the Max Planck Institute of Biochemistry have discovered that the protein kindlin-3 is altered in these people as a result of an inherited mutation, meaning that the receptor proteins in the white blood cells that serve as binding sites are no longer activated. The disease could be cured in the future by inserting a functioning kindlin-3 gene into the patient's cells.

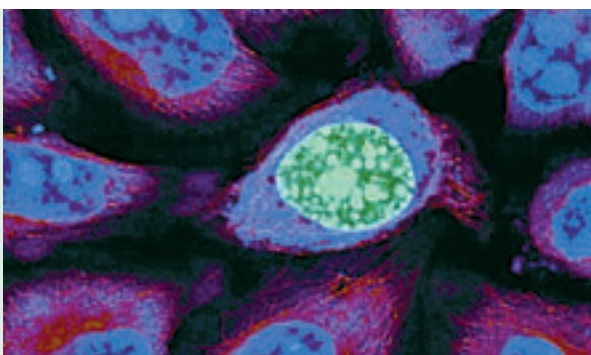
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Specialists from many different fields must work together to research rare diseases.

Research into the fundamental principles of rare diseases holds great opportunities. Patients can be confident that knowledge about the genetic causes is put toward finding new diagnostic possibilities. The basic sciences and the applied sciences are receiving a new impetus, because each newly identified human genetic defect underlines the relevance of signaling pathways and regulatory circuits, some of which are known and some of which are new. Shedding light on rare diseases also provides us with new perspectives which help to explain the development and function of our organ

systems. Because of the rarity of the diseases, international and interdisciplinary research networks are needed; this enables links to be formed between the different scientific disciplines and between cultures. The successful development of innovative molecular therapy strategies, such as gene therapy, was possible only on the basis of a comprehensive understanding of rare monogenic diseases. It is hoped that these first experiences of gene therapy will in the future also provide patients with common diseases with new chances of recovery.



#### Inflammatory diseases **Inflammation at interfaces**

The interfaces of the skin, lungs, intestines and mouth are the principal zones of interaction with the environment. They protect against harmful influences, absorb nutrients and shape the functional potential of populations, for example through gene variants in humans. Inflammatory diseases affecting these organs, such as asthma and psoriasis, have increased dramatically. This can be attributed to the interaction of genetic risk patterns, lifestyle and ageing processes. The discovery of the mechanisms which act on the organs and provoke disease is the starting point for exploring and developing new methods for the prevention and treatment of inflammatory diseases.

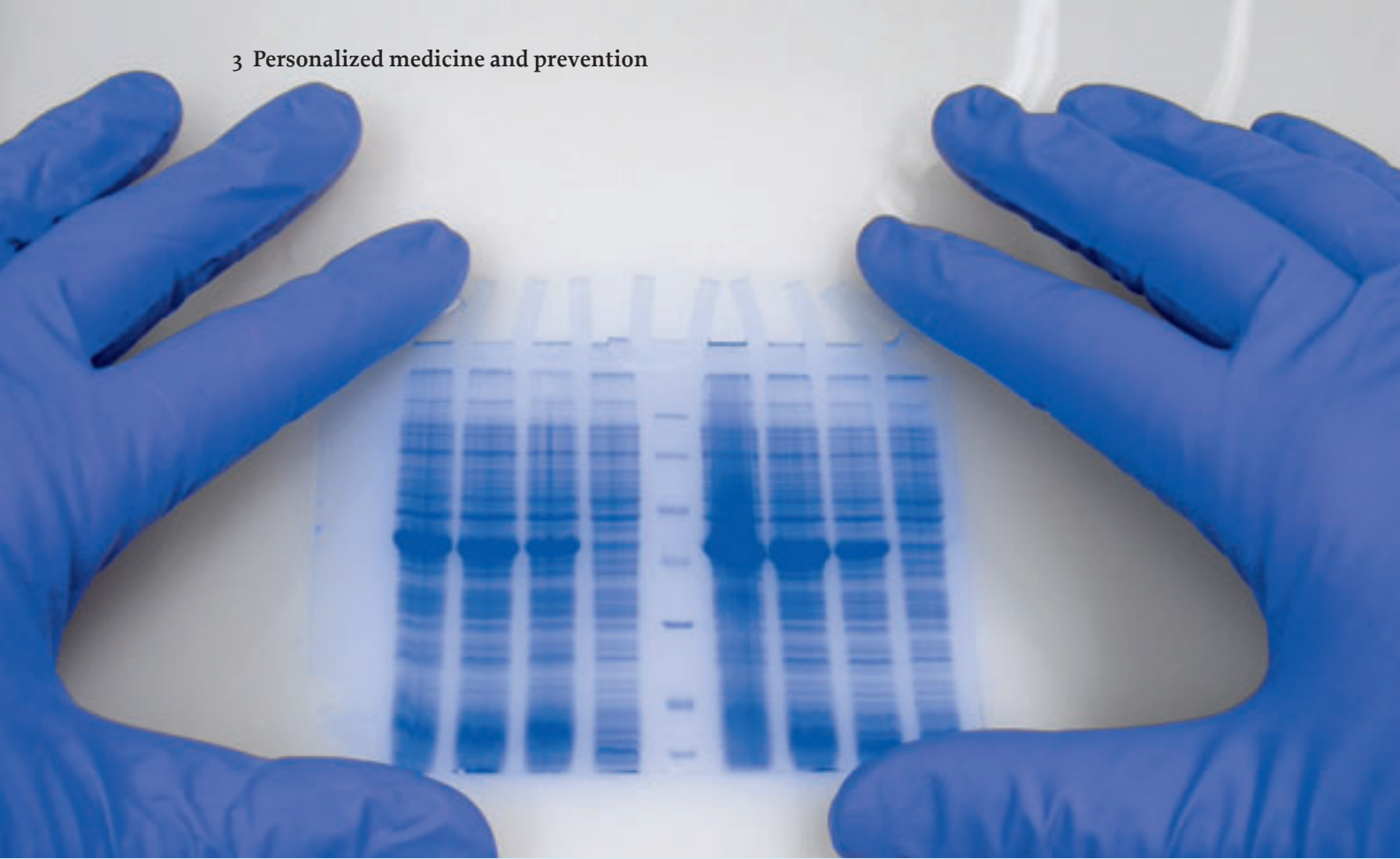
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#### Poverty-related diseases **Postgraduate courses for developing countries**

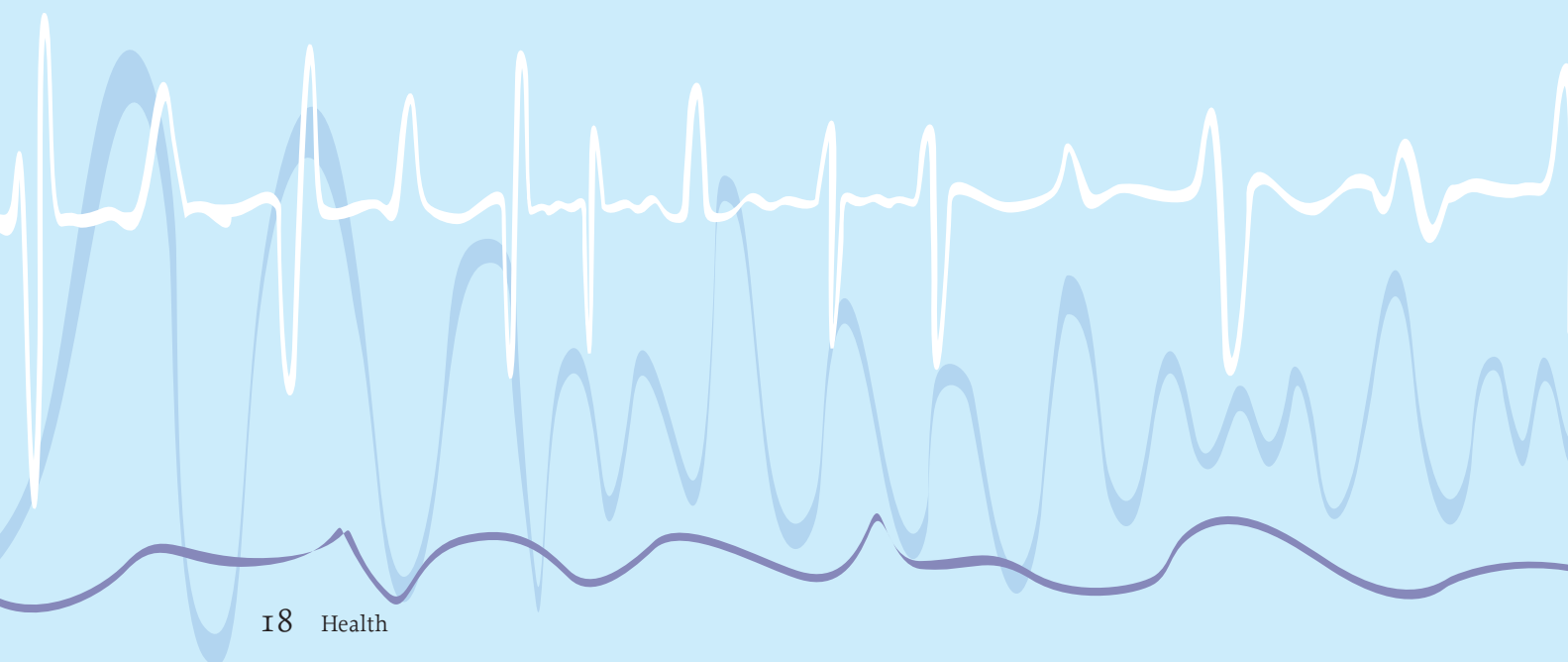
The German Federal Ministry for Economic Cooperation and Development is enabling future specialists and managers from developing countries to study at German universities and funding their study. This includes two English-language masters' programs in International Health. At the Charité in Berlin and the University of Heidelberg, young postgraduates from developing countries with experience in practical medicine not only acquire and develop skills for effectively treating poverty-related diseases and health problems, but they also learn about health policy, health economics and health management. The knowledge they acquire provides them with a wide range of career options, allowing them to make crucial advances in the healthcare provision in their home countries.

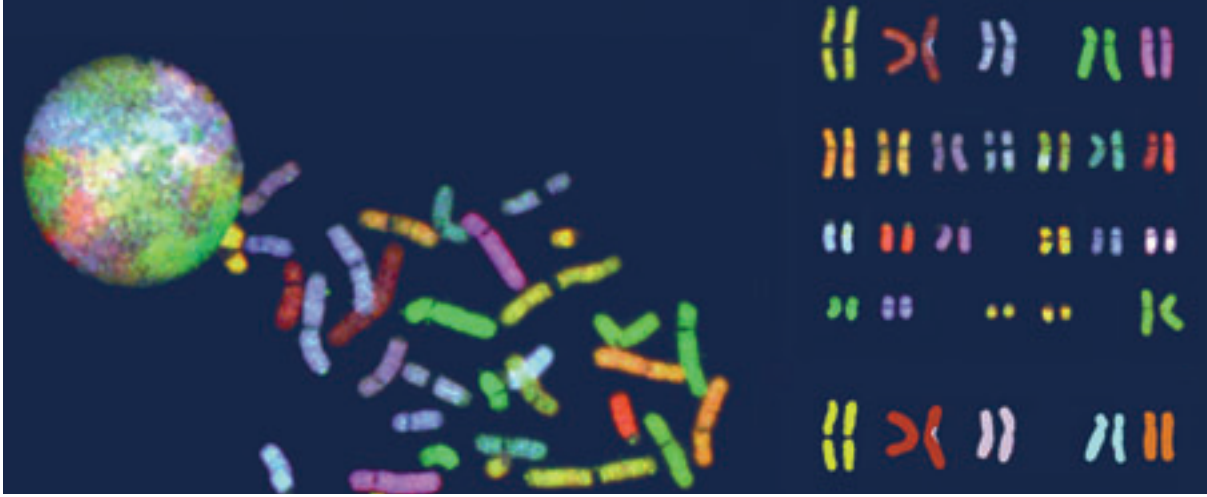
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## Major benefits – targeted effects

The risk of developing certain diseases is often formulated on the basis of generally applicable data, i.e. for the “average person”. This ignores the fact that every person has a unique genetic make-up, and these differences are compounded by widely varying lifestyles, diets and personal habits.





The human chromosome set.

## Personalized risk assessment

The risk of developing certain diseases is often formulated on the basis of generally applicable data, i.e. for the "average person". This ignores the fact that every person has a unique genetic make-up, and these differences are compounded by widely varying lifestyles, diets and personal habits. Personalized risk assessment has therefore taken on the task of determining the likelihood of a specific individual acquiring a disease.

Key questions in a risk assessment include: What can happen? How likely is it that this will happen? If it happens, what negative consequences will it have?

In order to determine the level of risk, factors which are not genetically determined are first of all used as an aid. In self-tests of this kind, such as the German Diabetes Risk Score (from the German Institute of

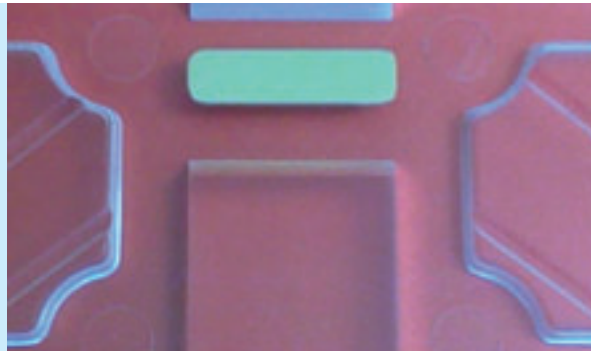


Diabetes research

### Customized prevention and treatment

Diabetes is one of the most common diseases and one of the most expensive to treat. However, if a person knows their personal level of risk, then it is possible to take steps at an early stage in order to at least delay the onset of the disease. Researchers at the Leibniz Association have therefore developed the German Diabetes Risk Score, which can already be used to calculate a person's individual risk of developing diabetes. As part of the German Diabetes Center study, they are currently looking for biomarkers and risk genes which can predict the probability of serious long-term consequences, such as a heart attack or kidney failure. At the same time, they are also working to further improve and customize diabetes prevention and treatment.

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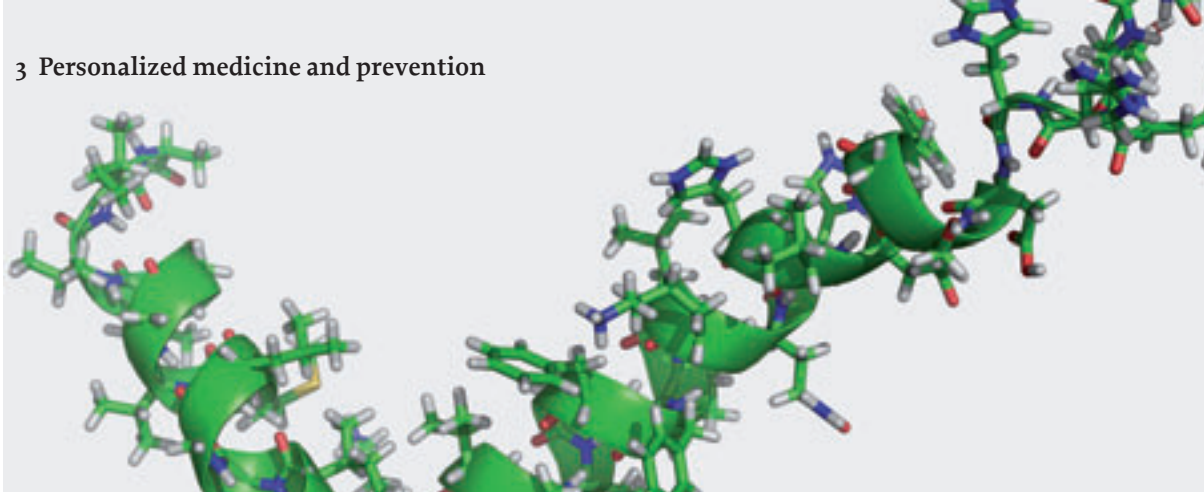
Micro-optical sensors

### Multipurpose detection tools

These analytical systems are important for rapid diagnosis in numerous different fields of application – from environmental analysis and food analysis to veterinary medicine, right through to human medicine. Micro-optical sensors provide a visual indication of the binding of specific pathogens or antibodies to specially prepared surfaces. One of the methods used for this purpose, known as surface plasmon resonance (SPR), has been developed to the stage where it is now possible to test up to 180 samples simultaneously on the gold surface of a disposable chip. This greatly improves efficiency, for instance when analyzing donor serum for the presence of antibodies to the cytomegalovirus or when searching for different DNA or RNA sequences.

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### 3 Personalized medicine and prevention



The amyloid beta 42 molecule plays a central role in the metabolism of the brain.

Human Nutrition), people are asked about lifestyle factors. The basis used for designing this questionnaire was a study with 27,000 participants. Individual criteria such as abdominal girth, age, dietary habits, smoking and other factors are used to determine the risk of developing type-2 diabetes within the next five years.

Research is increasingly focusing on genetic make-up as well. However, it is much more complex – and thus

also more difficult – to make statements which are universally valid. Even with five to ten risk genes, there is a very large number of recombination possibilities – each with different probabilities of occurring. In addition, some gene variants only take effect as a result of certain environmental conditions. Despite the challenge of precisely defining the individual effects and combinations, genetics is a rewarding and exciting field of research. It can be used not only to detect health

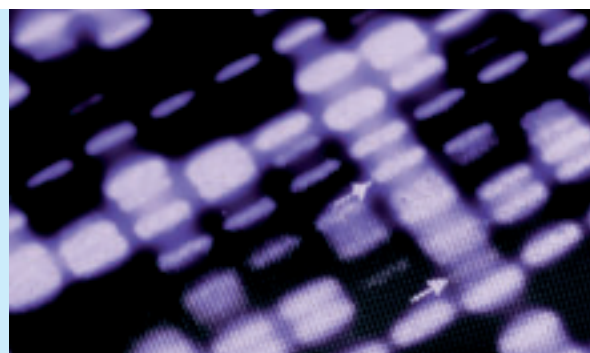


Cancer research

#### More strike power to fight cancer

How can the immune system be made to fight cancer more vigorously? Dr. Liang-Ping Li and Prof. Dr. Thomas Blankenstein from the Max Delbrück Center for Molecular Medicine (MDC) in Berlin-Buch and the Charité in Berlin have, in their ten years of development work, found a way to activate the receptors of specific immune cells, the T-cell receptors, so that they will no longer leave cancerous cells undetected but rather purposefully seek them out: the precondition for the immune system to be able to destroy them. They have developed a mouse that has a whole arsenal of these human T-cell receptors. The aim is to use these receptors for targeted immunotherapy in patients.

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Neurodegenerative diseases

#### Customized treatment of depression

Each case of depression is different. It is not just the symptoms which may differ from one person to the next, but the causes and trigger factors can also vary. In addition to risk genes which influence susceptibility to depression, personal experience also plays a major role. Scientists at the Max Planck Institute of Psychiatry are developing methods that can detect the disease process before symptoms appear. They decipher which genes are involved in the various different forms of depression and which genes influence the success of treatment with antidepressants. New therapies that are individually tailored to the patient should treat depression more effectively and be better tolerated.

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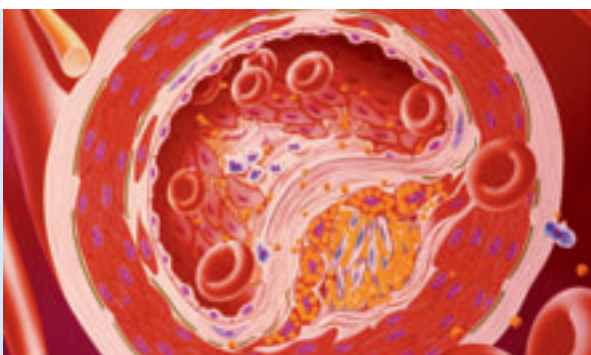


Conclusions can be drawn about an individual's various different characteristics on the basis of DNA.

risks early on, but also to take steps to combat these risks in good time. In this way, everyone can individually counteract their personal health risks.

## Developing new conceptual ideas for prevention, diagnosis and therapy

Attempts to understand diseases and their causes are increasingly successful thanks to intensive research. Basic research is of immense importance because, as our understanding increases, so too do the possibilities for intervention. Technological progress provides new starting points. An important milestone in this respect was the Human Genome Project in which, in



Cardiovascular research

### Gene variant determines cholesterol levels

Why do some people have a high cholesterol level and suffer a heart attack while others do not? Researchers at the Max Delbrück Center for Molecular Medicine (MDC) in Berlin-Buch and their colleagues in Denmark have found an answer to this: a gene is "at fault". It appears in different forms – one variant of the gene provides protection, another does not. Researchers led by Professor Anders Nykjær of Aarhus University and Prof. Dr. Thomas Willnow at the MDC were able to demonstrate that the gene in question (SORT1) determines how much cholesterol is released into the blood by the liver. People with an active SORT1 gene variant release a high amount of cholesterol and therefore have a higher risk of heart attack. People with a less active gene variant release less cholesterol, and are protected.

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Diabetes research

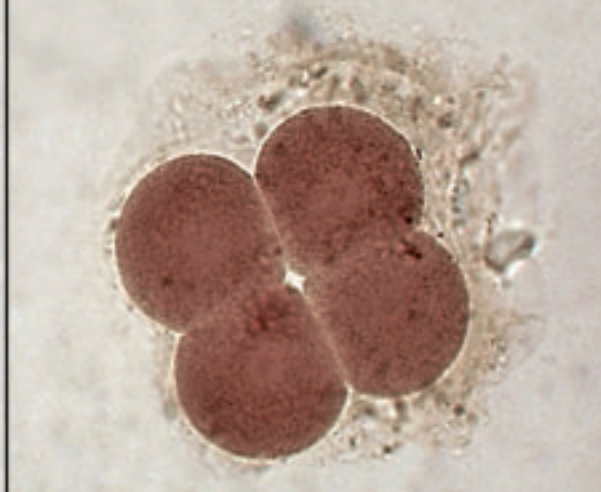
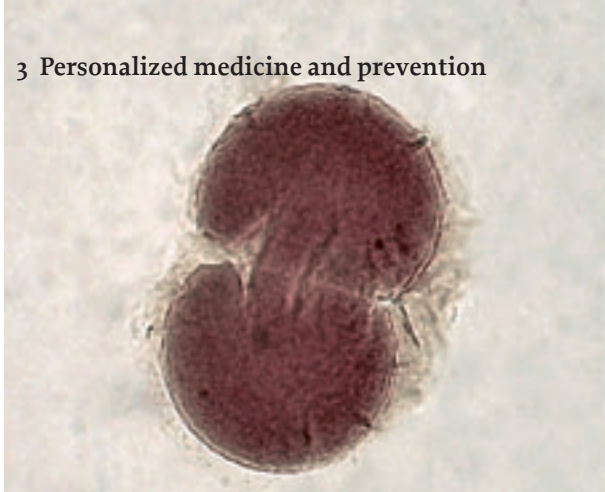
### Successfully combating diabetes

One of the main areas studied at the Helmholtz Zentrum München is the origin of the common disease diabetes mellitus. The study focuses on the relationships between an individual's genetic predisposition and environmental factors such as diet, lifestyle or pollutants. An understanding of the complex relationships is crucial for the development of new therapies, diagnostic procedures and prevention strategies. In order to meet the goal of fast translation and hence rapid benefits for patients, the Helmholtz Zentrum München has close links with the universities and hospitals in Munich. It is a partner in the German Center for Diabetes Research, which combines national expertise with the aim of providing patients with rapid benefits.

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### 3 Personalized medicine and prevention

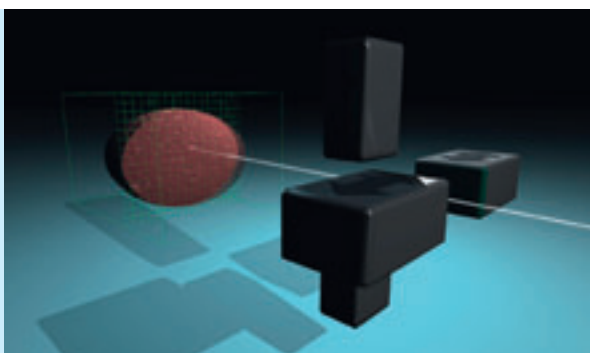
In pre-implantation diagnosis, embryos – seen here in the two- and four-cell stages – are subjected to genetic testing before implantation.



In the 1990s, scientists began among other things to systematically look for genetic characteristics of certain diseases.

The surprising discovery was not simply that there are significantly fewer genes than thought, but also that the interplay between the genes and their products – and thus also the genesis of common diseases such as Alzheimer's disease, depression and type-2 diabetes – is substantially more complex than previously believed. Scientists also realized that these diseases are not purely genetic in origin but have a strong environmen-

tal and lifestyle component in their development. Although the sequencing of the human genome has now been completed, classification and assessment of the findings continues. With targeted genome analysis of individuals, new mutations are constantly being identified as risk alleles. So-called personalized medicine, in which the risks of individuals developing certain diseases are identified or customized forms of treatment are used, is also making great progress. One topic which is currently the subject of much discussion in the context of early detection of diseases is what is known as pre-implantation diagnosis, which allows certain hereditary



Cancer research

#### Cancer therapy using ion beams

A new form of cancer therapy using ion beams has been developed by scientists at the GSI Helmholtz Centre for Heavy Ion Research, together with medical practitioners, and has been successfully used at the GSI. A total of 440 patients have been treated, with recovery rates of over 90 percent and very few side effects. Ion-beam therapy is precise and highly effective and is very gentle on the patient. This form of tumor therapy has been in routine clinical use at the Heidelberg Ion Beam Therapy Center (HIT) since November 2009. Scientists and technicians at the GSI developed and built the accelerator facility and radiation technology for the HIT. As part of a licensing agreement between the GSI Helmholtz Centre and German industry, further facilities are already under construction in Marburg and Kiel.

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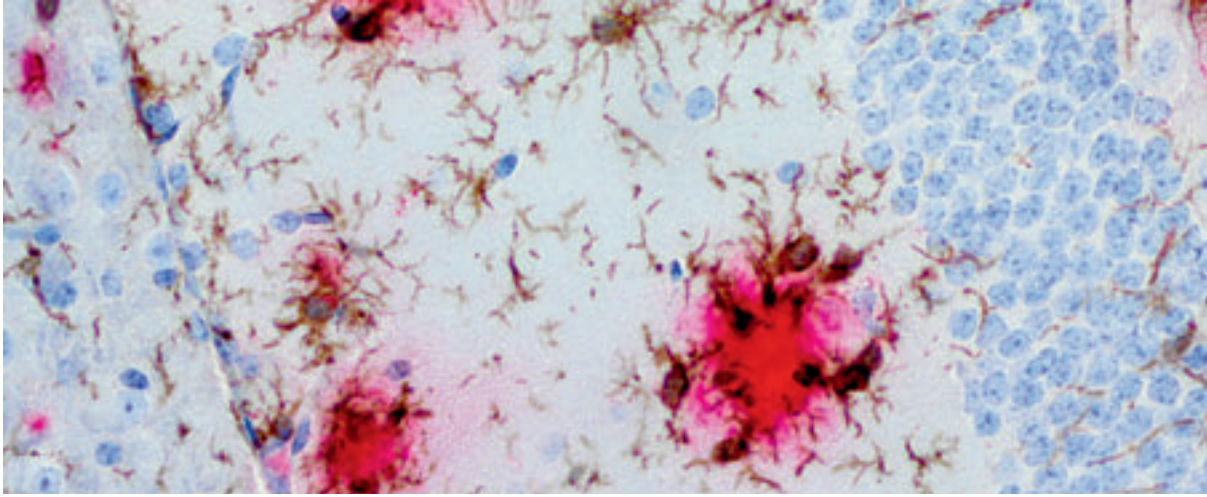
Prevention research

#### Using biosensors to detect diseases

By using sensitive biosensors in combination with the inert gas xenon, in future it may be possible for doctors to not only detect diseases very early, but for them to be able to check regularly whether medications are actually working in the patients using them. The established technique of magnetic resonance imaging (MRI) provides an image of the cell structure of the body. Leibniz researcher Dr. Leif Schröder is developing a novel method for visualizing processes in the body during an MRI scan. He uses a biosensor as a contrast agent that bonds to molecules in the body and which enables changes in their cell structure to be visualized. To pursue this research for the next five years, Schröder has been awarded nearly two million euros in research funding by the European Research Council.

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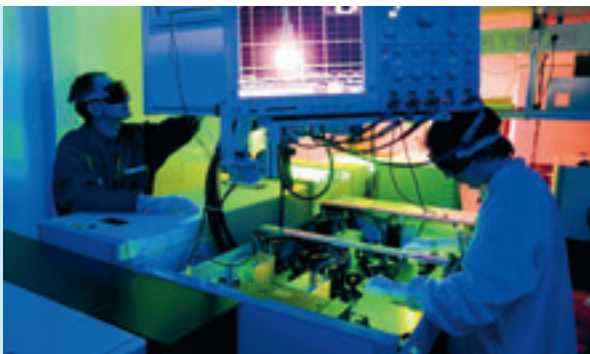


The brain of a mouse with Alzheimer's disease: The microglial cells evenly distributed throughout the brain (stained brown) are concentrated around the pathological Alzheimer's plaques (stained red).

diseases or chromosomal anomalies to be identified before implantation in in-vitro fertilization.

Now that we are able to detect predispositions, it is only a small step to being able to specifically influence the corresponding gene or its gene product. A large number of researchers are working toward this objective. One area of particular interest is micro-RNA: these molecules do not code for gene products themselves but assume regulatory functions by interacting with transcription factors. It is therefore hoped that it will

be possible to fight specific diseases, such as certain types of cancer, by developing drugs that target micro-RNAs. Another promising area is stem cell research. A cell which, in its undifferentiated state, is still capable of differentiation into any kind of cell offers the hope of completely new approaches to treatment. One possible application would be to transform stem cells into nerve cells in vitro and then transplant them to replace diseased or dead tissue – an interesting approach for neurodegenerative diseases such as Alzheimer's disease.

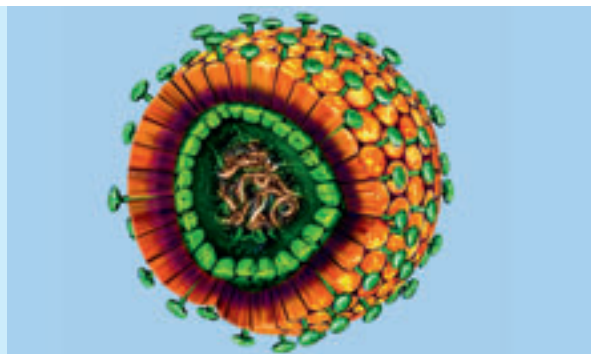


Cancer research

### Treating cancer accurately with laser beams

At the Helmholtz-Zentrum Dresden-Rossendorf (HZDR), particle acceleration using innovative laser technology is being promoted to enable the use of laser-accelerated protons in cancer therapy. When the ultra-short light pulses of a high-intensity laser encounter matter, particles are accelerated to enormous energies. In Dresden, this principle is being studied in order to develop compact devices for ion radiotherapy (therapy using electrically charged particles) which are suitable for the clinical environment. At the OncoRay Center in Dresden, researchers also aim to examine the effectiveness and intensity of the method compared with current large-scale equipment. In order to do this, conventional particles and laser-accelerated particles must first be tested in the same research laboratory.

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Autoimmune diseases

### When the immune system gets out of control

Our immune system is constantly fighting infectious agents. In the process, it sometimes generates autoimmune reactions which are often worse for the body than the actual pathogen. The brothers Dr. Karl Sebastian Lang and Dr. Philipp Alexander Lang, winners of the Sofja Kovalevskaja Award from the Alexander von Humboldt Foundation, are researching the causes of autoimmune diseases. At the University of Düsseldorf, Dr. Karl Sebastian Lang – together with a junior research group led by him – is looking for ways of minimizing the immune responses of an organism which target the organism itself. His brother Dr. Philipp Alexander Lang and his group are focusing their research on the effects of chronic viral infections on autoimmune responses.

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### 3 Personalized medicine and prevention

Biomarkers help to detect health risks early on.

But it is not just genetics which offers new ideas for approaches to prevention, diagnosis and therapy. Metabolic processes in cells, signaling pathways which can be blocked or activated, or even the influence of whole cell types are also interesting areas of research. The immune system is an important tool here and offers numerous opportunities for intervention: from a simple vaccination and administration of immunosuppressive drugs right through to the use of monoclonal antibodies, as with Crohn's disease. The development of biomarkers such as metabolic products, which

can be used for the early detection or even prediction of diseases, is becoming increasingly important. Thanks to new technologies and methods, the limits to what can be measured are constantly being revised downward.

As we now know, however, genetic and molecular make-up is not solely responsible for whether or not diseases appear. Environmental and lifestyle factors often determine the manifestations of diseases. This can be used to gain important insights, particularly in the



#### Neurodegenerative diseases **Researching mental health**

Prof. Dr. Jürgen Margraf is a leading expert in the field of clinical psychology. One of the areas he focuses on is the treatment of anxiety disorders. In 2009 he was awarded the prestigious Alexander von Humboldt Professorship by the Alexander von Humboldt Foundation. As the new Chair of Clinical Psychology and Psychotherapy at Ruhr University in Bochum, Margraf wants to use the five million euros of prize money to build a new research and treatment center there for mental health. His most recent work is aimed at learning more about protective factors for mental illnesses and thus defining positive conditions for mental health.

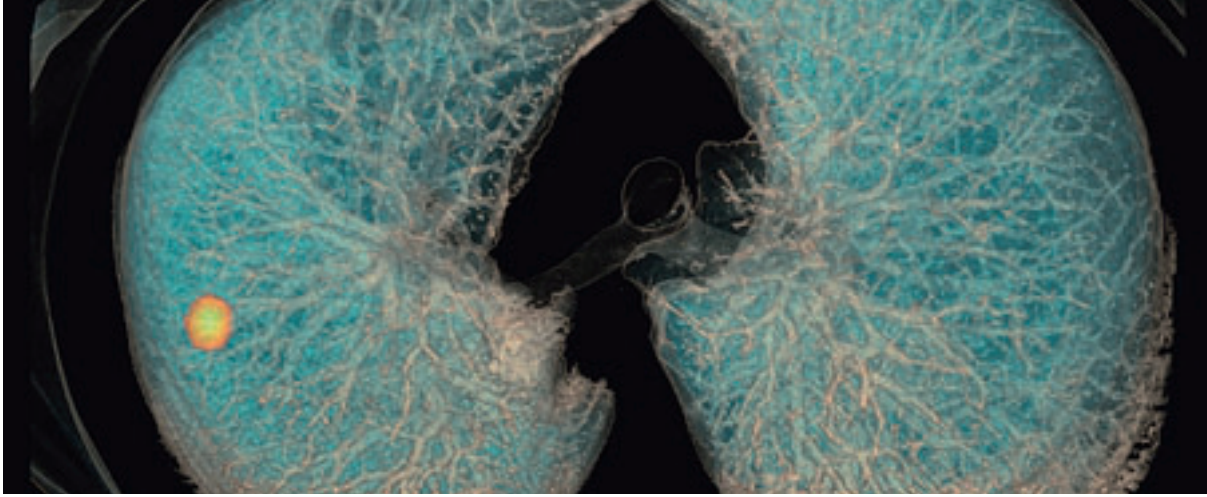
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#### Biomedical engineering **Developing diagnostic microsystems**

A rapid analysis of the patient's condition is necessary to support the medical diagnosis and to allow swift intervention by the physician (e.g. in emergency medicine). Researchers at the Fraunhofer Institute for Biomedical Engineering IBMT and the IHP – Innovations for High Performance Microelectronics are developing diagnostic microsystems which integrate all of the necessary processes into one device: from taking samples to transmitting the analytical information to the accident and emergency department. The currently achieved degree of miniaturization breaks new ground and enables the combination of on-the-spot sample analysis and signal processing with the subsequent transfer of this information to data nodes or networks.

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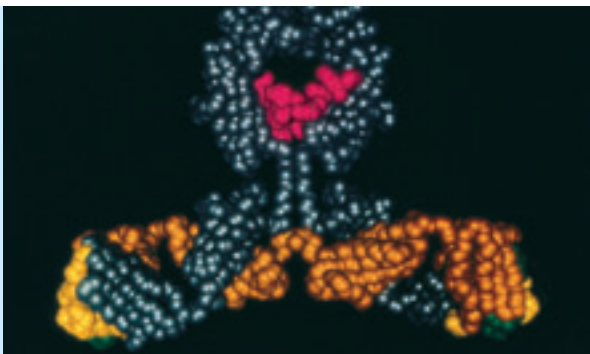
Combining 3-D X-ray images with positron emission tomography allows the location and size of lung tumors to be determined.

field of preventive medicine. So for example people who, thanks to genome analysis, know that they have a high probability of developing type-2 diabetes could take appropriate measures: adjust their diet, do exercise and avoid cigarette smoke.

Making diseases visible is not just a goal which is restricted to the molecular or genetic level, however; it is also an objective in the development of new imaging techniques. These techniques can enable diagnosis and therapy to be combined, a practice which is

already used for brain tumors. A precursor of hemoglobin administered orally as a contrast agent prior to surgery allows cancerous tissue to be distinguished using fluorescent light, thanks to the different metabolism of tumor cells.

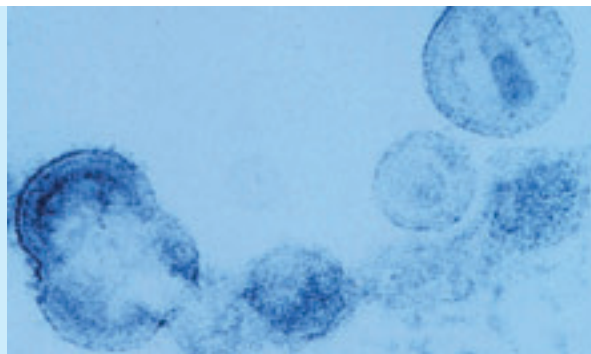
The flood of data collected using the new techniques, methods and approaches is enormous. That's why it is very important for science to collaborate and work together to link the knowledge gained in order to bridge the gap "from bench to bedside", from the laboratory



Cancer research  
**Drugs which block cancer signals**

Sometimes just a single change in the genetic material is enough for a cell to reproduce uncontrollably and become a tumor cell. Cancer researchers at the Max Planck Institute of Biochemistry are decoding the modified signaling substances which cancerous cells use to control their survival and growth. This means they can develop drugs that specifically block these growth factors and are tailored to the patient's particular type of cancer. This includes trastuzumab, for example. This antibody can halt the growth of cancer cells which have a specific receptor on their surface. Patients with this form of breast cancer can in many cases be successfully treated with trastuzumab.

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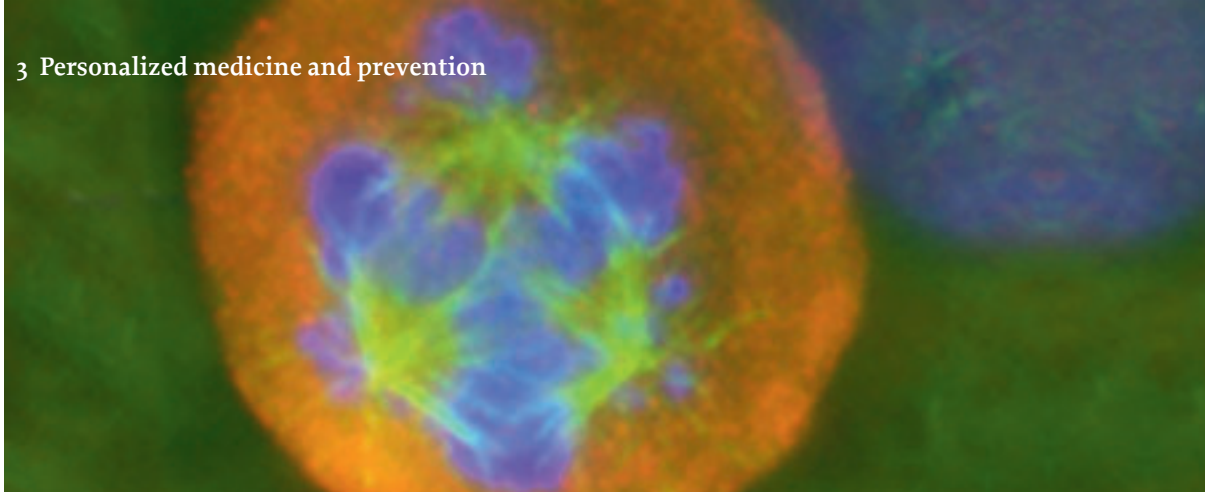
Infection research  
**Computing power in the fight against HIV**

H1 viruses are true masters of transformation. Mutations alter their genetic material, constantly giving rise to new variants. As a result, H1 viruses quickly become resistant to medication. Each HIV patient therefore carries viruses which have a distinct pattern of resistance against the various anti-viral drugs. Researchers at the Max Planck Institute for Computer Science provide software which can be accessed free of charge over the Internet, which determines the effect of the various medications in a patient. Doctors use the software to select a particularly effective combination of drugs for their patients before beginning treatment. The software is also able to estimate how the virus might develop resistance to a combination of drugs.

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### 3 Personalized medicine and prevention

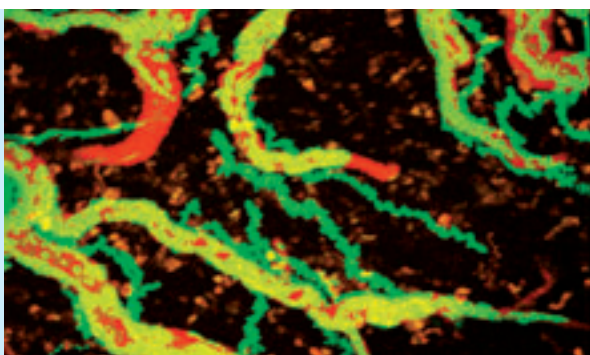
The multipolar, malformed spindle of a cancer cell.



to the patient, as quickly as possible. Translational research is also the task of the newly founded German Centers for Health Research, which have been created by the German Federal Ministry of Education and Research for common diseases – diabetes, cancer and pulmonary, cardiovascular and neurodegenerative diseases – and which pool the strengths of Germany’s research community.

### Diagnostic and predictive biomarkers

Even since ancient times, biomarkers have been used to diagnose diseases – which is also where the name diabetes mellitus, “passing honey”, comes from. Early diagnosis enables early treatment, especially before complications arise. Predictive biomarkers are therefore particularly important: characteristics which can be recognized even before a disease manifests itself. Finding molecular biomarkers has been made considerably easier by new technologies such as metabolomics.



#### Multiple sclerosis Attacked by the immune system

In patients with multiple sclerosis, their immune system also turns on their own body and attacks the nervous system. The reasons for this misguided attack are still largely unclear. At the Max Planck Institute of Neurobiology, scientists are investigating the basic processes and features of multiple sclerosis. Using modern methods, they are able to track the migration of pathogenic immune cells in living organisms. They have discovered new attack points for immune cells, activation mechanisms for particularly aggressive immune cells and how immune cells invade the nervous tissue. The results contribute towards a better understanding of the disease and help to develop new and more effective therapies.

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#### Stem cell research Optimized Allogeneic Lymphocyte Therapy

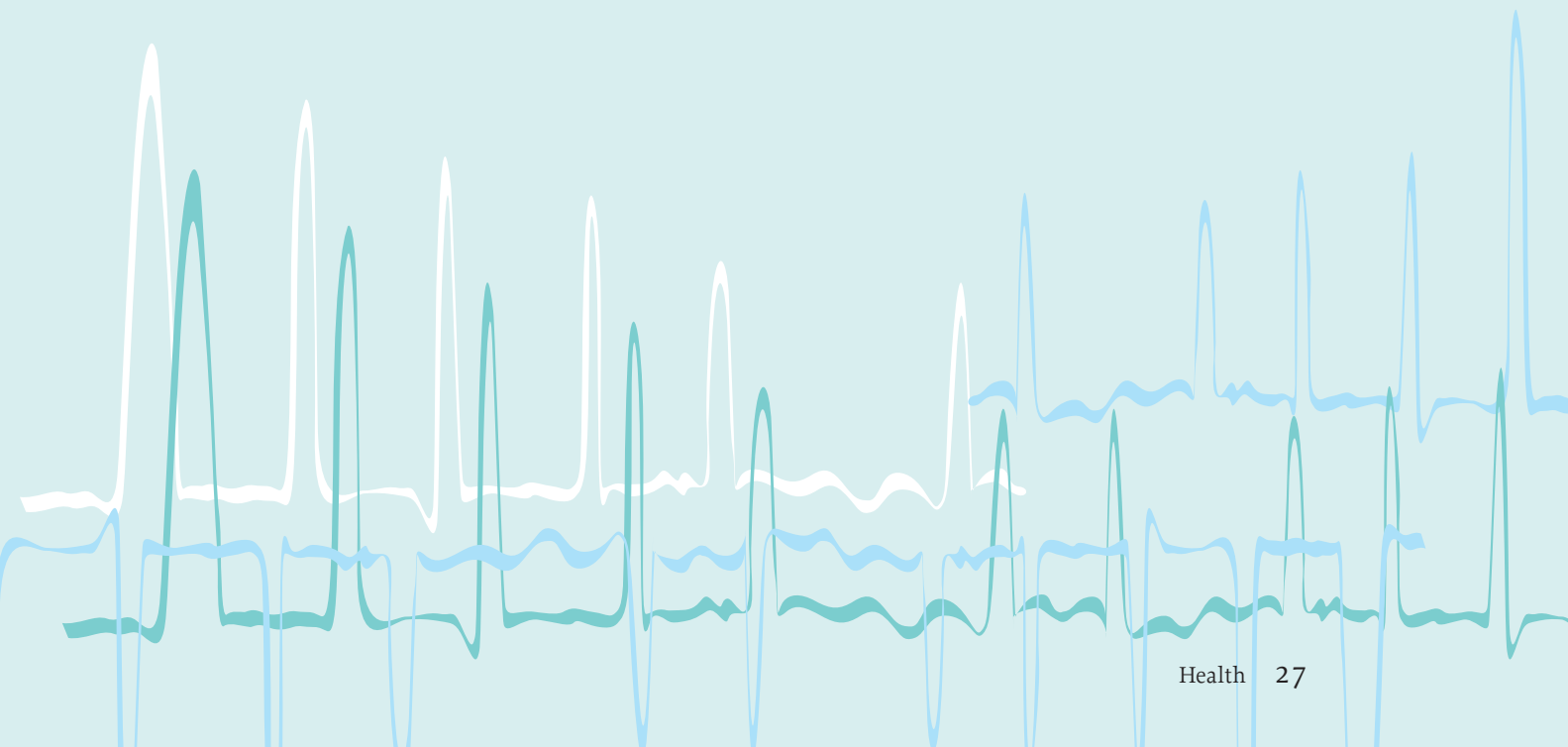
Leukemia cases which can no longer be treated using chemotherapy can be cured by transplanting bone marrow stem cells from a matching donor. This replaces the patient’s immune system with that of the stem cell donor. As well as triggering the desired immune response to the leukemia, this exchange also causes adverse reactions to healthy body tissue. The research group KFO 183 aims to strengthen the defense against leukemia and pathogens by modulating the key functions of T-lymphocytes and donor natural killer cells. Another aim of the group is to avoid rejection reactions. New therapy concepts designed to reduce the complication rates of stem cell transplants are currently undergoing clinical tests.

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## Increasing personal responsibility

Primary prevention programs are becoming increasingly important as a means of reducing the impact of chronic diseases at the individual, institutional and societal level. Moreover, roughly 25 to 30 percent of today's healthcare spending – as calculated in a study commissioned by the German Federal Ministry of Health – could be avoided by longer-term prevention. Prevention is also a major cost factor.



#### 4 Safeguarding health in everyday life

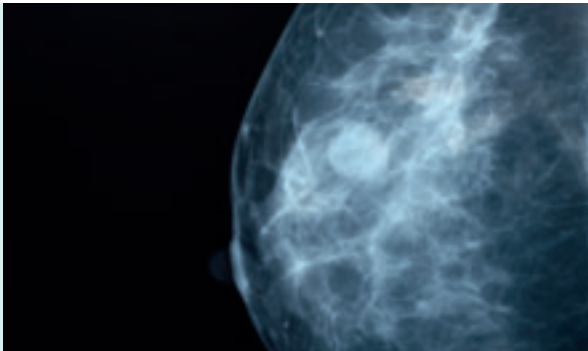


Health programs help people to eat wisely.

## Imparting the necessary knowledge to improve preventive behavior

Scientists researching prevention are therefore not only interested in finding out what behavior is the healthiest. They are also exploring what lies behind continued negative behavior, which is often against a person's better judgement. It is probable, for example, that ever since the Stone Age, our taste genes have had a major impact on the types of food we prefer.

Researchers at the German Institute of Human Nutrition are currently studying the extent to which biological mechanisms influence our choice of food today. Food is also the subject of the internationally funded IDEFICS study, which is coordinated by the Bremen Institute for Prevention Research and Social Medicine and develops prevention programs for tackling childhood obesity. As part of the study, the programs have additionally been implemented and evaluated in order



Prevention research

### Well informed about cancer screening

The relationship between physician and patient used to be one-sided: the physician was the expert and decided the treatment. Today, many patients value being involved in the decisions made by the physician. However, this assumes that the patients in question are well informed. Scientists at the Max Planck Institute for Human Development are investigating how much the general public in Europe understands about cancer screening. According to their research, 98 percent of German women overestimate the benefits of breast cancer screening by at least tenfold or do not know. Men overestimate the benefits of prostate cancer tests by a similar amount. The suitability of the information sources must therefore be investigated and improved.

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Neuroscience

### The memory function of sleep

The most fundamental feature of sleep is the loss of consciousness and control over behavior. Recent research has shown that deep sleep plays a central role in memory formation. This link has been discussed since experimental memory research began. Now we finally have evidence to prove that temporarily stored information is indeed actively transferred during sleep from the temporary to the long-term store. It can also lead to qualitative changes in memory content by adapting to existing long-term memory content. Today's research shows for instance how sleep can be used in various situations to strengthen memory and the ability to solve problems and also to strengthen cognitive functions in general.

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Obesity can lead to serious health problems.

to be able to identify measures which are effective in tackling obesity.

Medical examinations to screen for cancer could be one important preventive measure – but how well do patients estimate their actual benefits? This question was posed by researchers from the Max Planck Institute for Human Development. The result: almost all Germans either overestimate the benefits of screening

by at least tenfold or do not know. In this area and in many other areas in need of improvement, prevention research still has some way to go to convince consumers and patients to take a more responsible approach to their own bodies.



Prevention research  
**Preventing childhood obesity**

We are witnessing a global obesity epidemic which is even having a serious effect on children. As a result, a new generation seems destined to suffer serious health consequences from an early age. However, of all age groups, primary prevention measures promise most success amongst children. The IDEFICS study, coordinated by Bremen epidemiologist Prof. Dr. Wolfgang Ahrens, is not only investigating the causes of obesity in over 16,000 two- to nine-year-old children in eight European countries, but it is also developing, implementing and evaluating prevention programs with the goal of making evidence-based measures available to government policy-makers, health and education administrators, and families.

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Prevention research  
**National cohort to investigate the genesis of common diseases**

Common diseases such as cancer, diabetes, cardiovascular diseases, dementia and infectious diseases are the focus of Germany's largest nationwide population study to date. The national cohort will include more than 200,000 people. All participants will be medically examined several times and asked about their life-style habits. The data gathered and the blood samples stored can be used to study the causes and genesis of diseases. More than 20 universities and research centers are involved in setting up the cohort. The project is coordinated at the Helmholtz Zentrum München and the German Cancer Research Center in Heidelberg.

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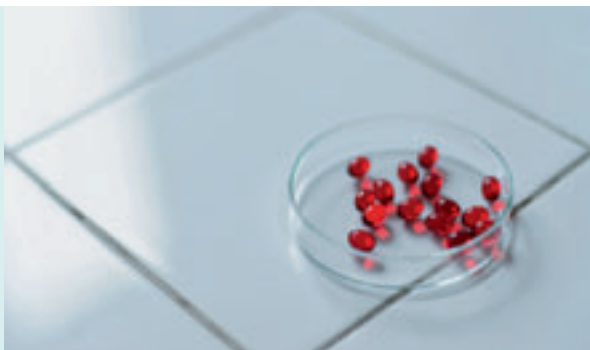


Food at work is rarely a balanced meal.

## Exchange between physicians, scientists and patients

The scientific community strives to translate its findings as quickly as possible into diagnosis, therapy and in particular prevention. This requires dialog between research and practice. People either need to change unhealthy behavior patterns or should not start them in the first place, and they must view their health as a competence; doctors could concentrate more on giving advice to healthy people and taking preventive measures. Dialog between doctors and patients is extremely important for successful treatment. In medical studies

which look at this, the focus is mainly on the personal approach, which has health benefits. Linguistic science also deals with doctor-patient discussions, however. In conversations with patients, five key components can be identified: the opening, the discussion of symptoms, the diagnosis, the treatment planning and the conclusion of the conversation. The beginning in particular sets the scene – it is an essential element in building a relationship.

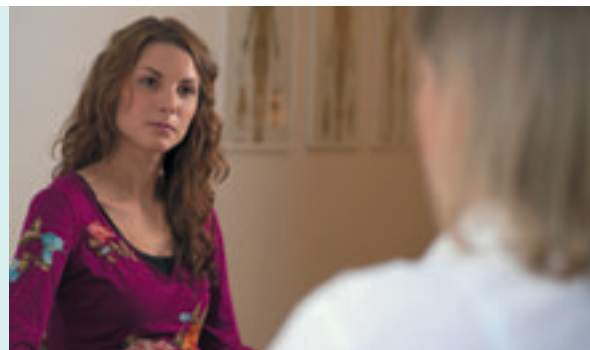


Prevention research

### Identifying risks associated with medication

Clinical studies for the approval of drugs cannot detect rare risks associated with medication. This is usually only possible after their approval and with the help of large pharmaco-epidemiological research databases. Bremen-based epidemiologist Prof. Dr. Edeltraut Garbe of the Bremen Institute for Prevention Research and Social Medicine has set herself the task of developing a nationwide research database of this kind in order to enable drug risks to be systematically investigated in Germany. In collaboration with German health insurance funds, she has succeeded in collating routine data from approximately 14 million people. This database will be used, for example as part of a large European study, to investigate the gastrointestinal and cardiovascular risks of strong analgesics in the treatment of rheumatism.

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Doctor-patient communication

### Any more questions?

In medical consultations, the patient is asked a question on average every 15 seconds. But how do things look when it comes to mutual understanding? A great many factors complicate communication: time pressures often place limitations of the length of the appointment, and yet at the same time doctors are supposed to document consultations on the computer system. But talking really does help. In medical studies which look at this, the focus is mainly on the personal approach, which has health benefits. But doctor-patient conversations can also be analyzed using methods borrowed from linguistic science. This has been done at the Institute for the German Language in Mannheim. Results from the work may help doctors to explore symptoms in more detail and increase patient satisfaction.

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Lupin seeds have a very high nutritional value.

## Nutritional research and the development of new and functional foods

Functional foods are foods which, in addition to their nutritional value and flavor, are said to have a positive influence on health and well-being or to reduce the risks of diseases. It is already more than ten years since the first functional foods came onto the market, which has been growing ever since. The first products included pro-biotic yoghurt and sports and energy drinks. Then in 2000, a margarine fortified with plant sterols and proven to reduce cholesterol levels was

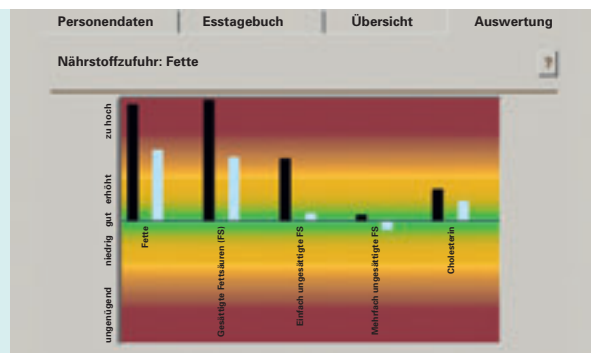
developed for the first time. Researchers in various institutes and projects are currently working on creating a scientific basis for new product ideas. Or they are developing techniques which first make the production of new food innovations possible. For example, taste researchers at the German Institute of Human Nutrition, a member of the Leibniz Association, are searching among other things for substances which can intensify the flavor of salt.



Nutritional research  
**On the trail of taste preferences**

Many people prefer unhealthy foods that are too fatty, too sweet or too salty. The reason behind this is the subject of research by scientists at the Leibniz Association, who are studying the genetic, molecular and food chemistry aspects of taste perception. As their data shows, variations in taste genes were probably already influencing dietary behavior, and thus human evolution, back in the Stone Age. The extent to which gene variants and also flavorings influence our choice of food today is currently being studied. Even now, however, the research data can already provide a scientific basis for improving the flavor of dieting products.

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Nutritional research  
**Supporting decisions at the fridge door: CENA**

CENA is a software application which heightens your understanding of your eating habits and makes suggestions for improvements, providing easy and efficient assistance with nutritional issues. Users have to keep a food diary and provide details about work and sporting activities, illnesses and specific food preferences and dislikes. CENA first of all processes this information to produce a graph, analyses the nutrient supply both generally and for individual groups (vitamins, fats, etc.) and compares the results with a desirable state. The program then gives the user suggestions for learning healthy eating habits and if necessary also for losing weight.

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#### 4 Safeguarding health in everyday life



Low-fat sausage – with less than 3 percent fat.

Products which are low in salt but which still taste good would be of particular benefit to those people who have to stick to a low-salt diet for health reasons. Healthy people also benefit from foods which are low in salt, however, since daily salt intake exceeds the salt requirement even in a balanced diet.

A new production process developed by the Fraunhofer Institute for Process Engineering and Packaging IVV enables sausages to be produced which are significantly lower in fat. Products such as this may in the

future contribute towards reducing the consumption of unhealthy fats. And here's another example: researchers at the TU Berlin have developed a friendly production method, which conserves the nutritionally valuable ingredients in vegetable oils in larger quantities than normally present in the oil. These substances also include plant sterols.

Microbiologists and bioanalysts at the Technical University have also developed an artificial intestine, which they plan to use to study the health benefits of new



Nutritional research

#### **Fitness sausage: low-fat and tasty**

When it comes to sausages, Germany is the best in the world: no other country offers as many different varieties of sausage. Many people don't want to sacrifice this tasty food, but they would still like to eat healthily with fewer calories. Until now, however, boiled sausages have had a relatively high fat content for reasons of flavor. Together with a master butcher from the Allgäu region, Fraunhofer researchers have developed a method for producing sausages which are particularly low in fat but which leave nothing wanting when it comes to the flavor. The new varieties have less than 3 percent fat. So tasty can also mean healthy.

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Nutritional research

#### **Proving the functionality of ingredients in food**

The development of foods with added benefits (functional foods) is taking on an ever greater significance for the prevention of diseases. Scientific proof of the functionality of foods is of great importance here. The objective of the project is to establish a bioreactor-based model intestine to simulate the different sections of the digestive system. The aim is to make observations about the health benefits of foods with the aid of the microbial and enzymatic fermentation model. The model intestine will be used for the first time in the development of new alcoholic drinks produced by controlled fermentation of mixed cultures.

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**Innovative research on sustainable production in agriculture.**

beverages. Model systems such as these are important because it is often difficult to study the effects of functional foods directly on humans. Scientific evidence to demonstrate functionality is of great importance, however.

Other scientific innovations can also help people to eat more healthily. The Fraunhofer Institute for Industrial Mathematics ITWM has created nutritional advice software which gives users tailored advice on how to improve their diet. And in a sub-project of the

state-funded competence network "Value Creation in Horticulture", the Leibniz Institute of Vegetable and Ornamental Crops is investigating how natural functional foods can be produced in the fresh vegetable product sector. Everyday foods can contribute in this way to the health of consumers.



Nutritional research  
**Developing new production concepts for valuable oils**

Consumer demand for healthy foods has led to a re-think of production processes. A gentle, non-thermal treatment process was studied by the TU Berlin and is based on the use of high-voltage electrical pulses. The method for processing vegetable oils (e.g. maize germ oil, sunflower oil, rapeseed oil) is particularly interesting, as besides several unsaturated fatty acids these oils also contain cholesterol-lowering, anti-carcinogenic and thus nutritionally valuable ingredients (such as phytosterols). The method simplifies process steps such as extraction and pressing and enables the phytosterol content to be increased by 24 percent.

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**Lupin seeds, with and without their husks – a natural source of cholesterol-lowering proteins.**  
 © Fraunhofer IVV

Nutritional research  
**Cholesterol-lowering protein from lupins**

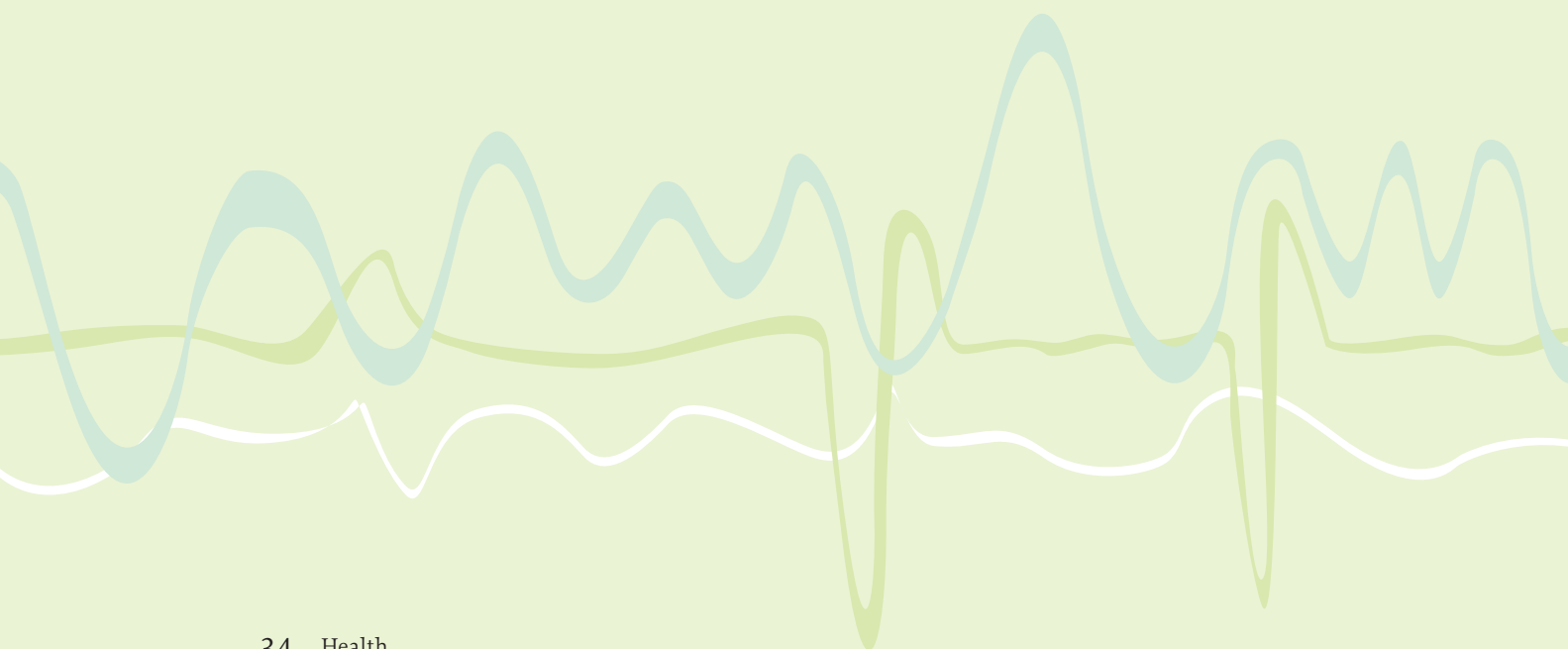
Sweet lupins are a valuable raw material for food production. Scientists have been able to develop a protein isolate from the seeds which has very good techno-functional and sensory properties. This protein has also exhibited physiological effects: initial studies on people with moderate hypercholesterolaemia showed that lupin protein lowers LDL cholesterol levels compared with casein. In experiments with animal models, lupin proteins were also able to reduce liver fat content. These effects are particularly pronounced in cases where blood fat levels are excessively high. Lupin protein particularly influences the LDL receptors and regulators of lipid metabolism.

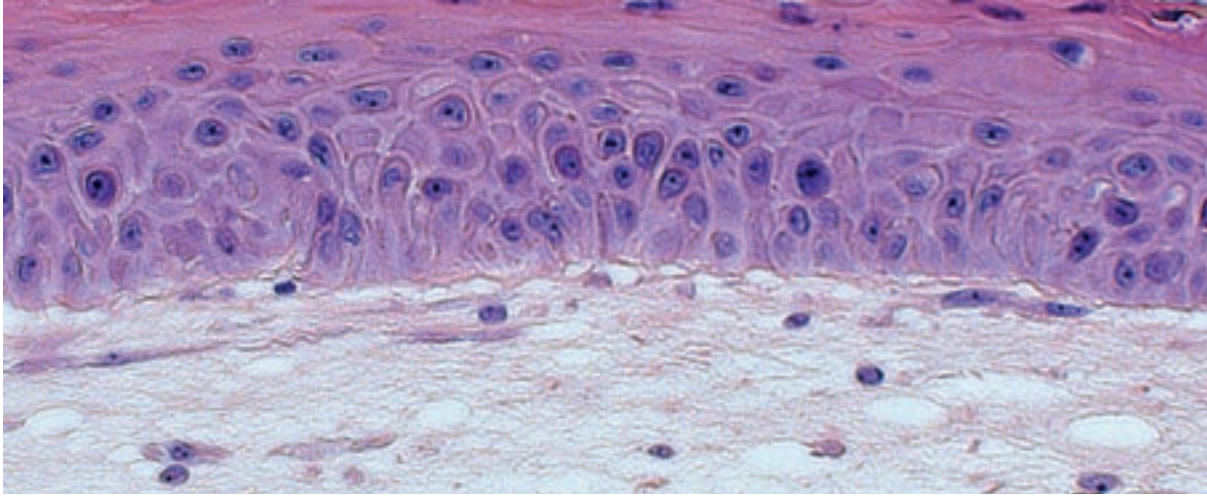
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## Using technology and biology to improve medicine

The medical needs of a post-industrial society are shaped by the changing age structure and the lifestyle of the population. Regenerative medicine is therefore an ever-growing objective of biomedical research. It is aided by advances in stem cell biology and biomedical engineering.





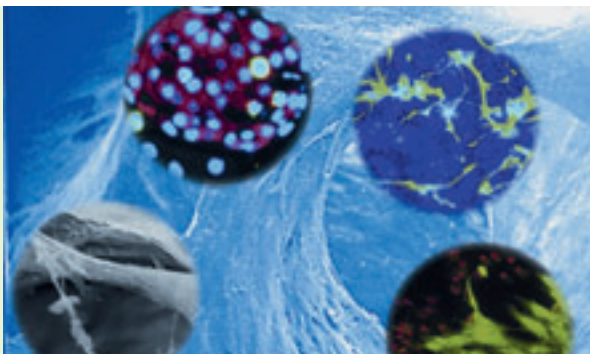
Skin is composed of several layers of cells.

## Regenerative medicine (best practice)

In principle, there are three ways of improving or restoring the function of diseased organs with the help of regenerative therapies. One method uses regenerative agents and biomaterials for inducing endogenous regeneration; another method is cell transplantation; and the third uses ex-vivo tissue engineering with subsequent implantation of a functional tissue portion, with the ultimate goal of fully creating an autologous organ in vitro.

**Endogenous regeneration** plays an essential role as a physiological repair process in recovery from organ or tissue dysfunction suffered as a result of trauma, inflammation, ischemia or degenerative processes.

One crucial precondition for this is the function of tissue-resident and circulating stem cells. Excitation of these stem cells using regenerative agents for the tissue-specific regeneration of functional cells is the prominent subject of future strategies. **Cell-based**



### Stem cell research On the path to the future of medicine

Thanks to rapid developments in molecular and cell biology research in recent years, future medicine will be able to benefit from a completely new therapeutic approach: regenerative therapies. These therapies make use of the body's ability to heal itself – a process controlled largely by stem cells. At the DFG Center for Regenerative Therapies in Dresden, research is being conducted into the regenerative potential of stem cells to replace diseased cells and even entire organs. This research is focused on the areas of hematology, diabetes, neurodegenerative diseases, bone and cartilage replacement and cardiovascular diseases. The aim is to translate the findings in cooperation with medical practitioners into regenerative therapies for humans.

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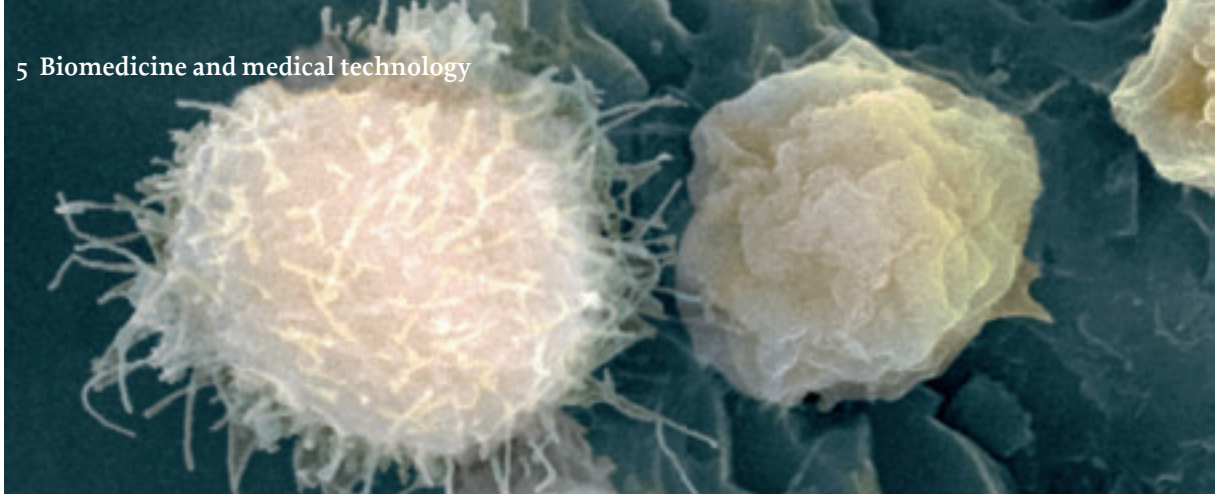


### Biomedical engineering Factory-made skin

Artificial skin from the laboratory is in demand. Manufacturers of pharmaceuticals, chemicals, cosmetics and medical devices need it to test the compatibility of their products. The largely manual production of skin models is an expensive and labor-intensive process, however. A team of researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB has succeeded in fully automating the entire process chain for manufacturing two-layer skin models. The skin models, which are produced in the first fully automated production facility, can be used for testing chemicals and can replace animal testing. The long-term plan is that the plant will also enable production of transplants for regenerative medicine.

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## 5 Biomedicine and medical technology

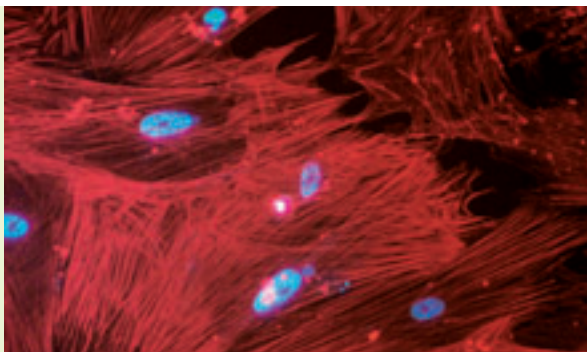


Stem cells will be used in future to cure diseases.

**therapies** are already in clinical use. With the reprogramming of adult cells to produce so-called iPS cells, a breakthrough in the source of cells for autologous cell transplantation is just around the corner. Their differentiation potential is immense, but potential tumorigenesis and the expansion of these cells to replace relatively large sections of tissue and even entire organs are still the subject of intensive research.

**Tissue engineering** is based on findings from research on endogenous regeneration and stem cell therapy.

Its aim is to develop methods for producing functional, implantable organotypic structures customized to the needs of individual patients in terms of dimensions and tissue compatibility. It is very possible that aspects of in-vivo regeneration, such as achieving terminal functionality after implantation, or principles of stem cell therapy, such as optimization of cell sources and their differentiation and expansion, may be used here. Concepts such as these have already been used successfully for treatment in a number of clinical disciplines, such as surgery involving cardiac valve replacement.



Stem cell research

### Fully-grown all-rounders

Early embryonic stem cells are totipotent. This means that they are capable of developing into cells of any tissue type in the body. This makes them very interesting for regenerative medicine. To avoid the necessity of harvesting stem cells from embryos, researchers at the Max Planck Institute for Molecular Biomedicine are looking for ways to restore adult cells to a similar state. Using the Oct-4 protein, they are now able to convert stem cells from the brain into unspecialized all-rounders. Induced pluripotent stem cells (iPS cells) are widely seen as ethically acceptable. They are being studied to determine whether they can be used for the treatment of injuries and diseases such as heart attacks, paraplegia and Parkinson's.

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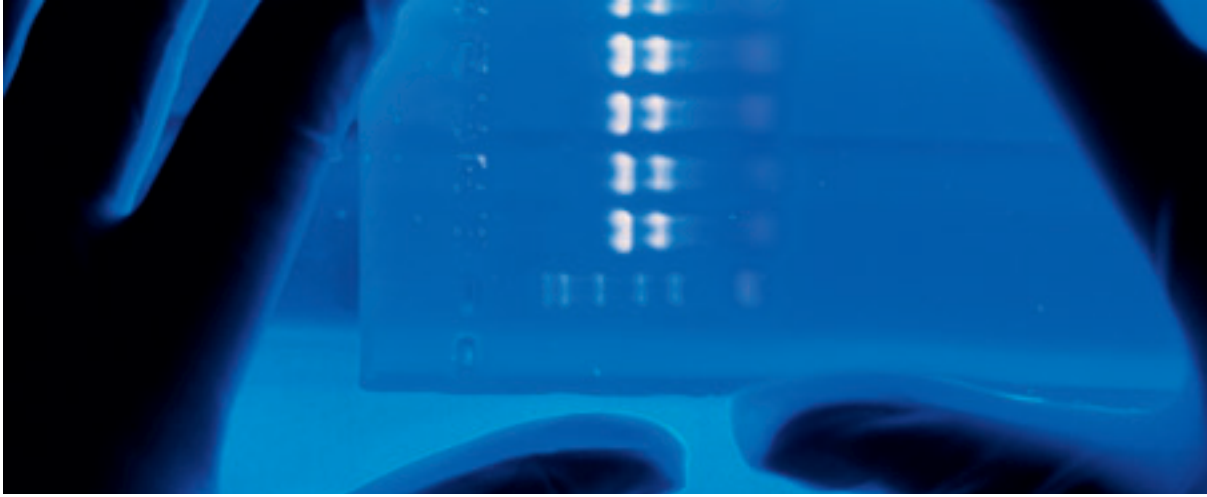


Biobanking

### Preservation at low temperatures

More than ten years of interdisciplinary research in cryobiotechnology have resulted in the Fraunhofer BioArchive, the biobank network at the cutting edge of global technology research, which is hosted by the Fraunhofer Institute for Biomedical Engineering IBMT. The commercially available biobank technology platform is based on more than 40 patent families. The most well-known biobank at the Fraunhofer IBMT is the HIV Specimen Cryorepository, which supports the worldwide search for a vaccine against HIV on behalf of the Bill & Melinda Gates Foundation. The Fraunhofer IBMT is a system provider for therapeutically and diagnostically orientated biobanks and offers services to partners in industry and research including the development of new cryomedia, optimized freezing records, order storage, and the design and validation of cryobanks.

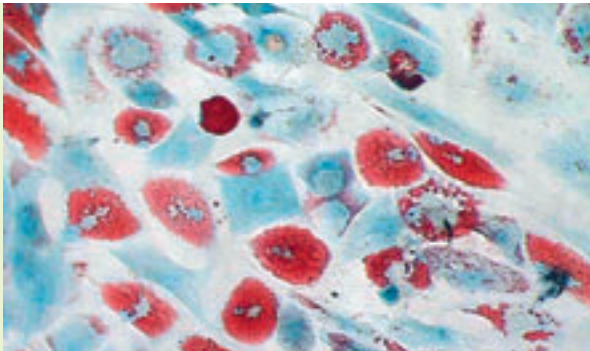
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DNA sequencing information is essential for further research progress.

## Diagnostic markers

Diagnostic imaging makes use of innovative biomarkers to visualize functional relationships in tissue. The processes used in laboratory medicine have become increasingly sensitive and robust as a result. Highly sensitive test procedures which can be carried out at the patient's bedside (point of care) are important here. In addition to biomarkers derived from serum, cellular and intracellular biomarkers such as non-protein-coding RNA biomarkers, which yield cell-type specificity, for example, are of increasing interest.



### Biobanks

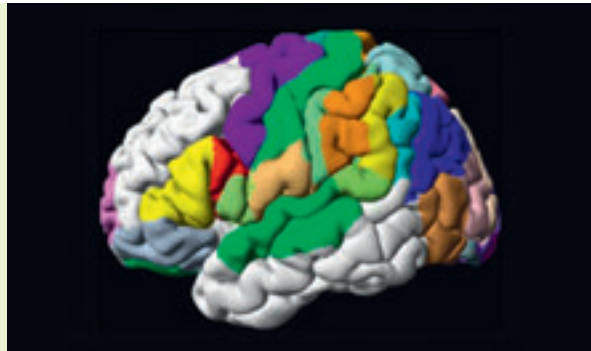
#### Using stem cells as a research tool

The Fraunhofer Institute for Cell Therapy and Immunology IZI has created special biobanks for cells from inflammatory tissue, such as tissue samples from patients with articular complaints such as arthritis. These cells are a valuable research tool for investigating the stages of development and responsiveness to new drugs and for characterizing new biomarkers. A new field of research deals with establishing stem cell banks from healthy tissues or malignant tumors. New methods of isolating tumor stem cells and of using cell cultures for drug testing have been developed at the Fraunhofer IZI for more effective chemotherapy treatments. It is already evident that tumor stem cells for traditional chemotherapy treatments exhibit a different reaction pattern to that of most other tumor cells.

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## Imaging techniques

Just as telescopes allow us to see distant galaxies and microscopes reveal the world in the minutest detail, brain research instruments make the structures and functions of the brain visible. The introduction of imaging methods such as positron emission tomography (PET) and magnetic resonance imaging (MRI) has established a new era of brain research in the last twenty years. Neuroscientists can use these and other instruments to study the structure and function of the brain



### Brain research

#### The virtual human brain

In the human brain, up to 100 billion neurons communicate with each other, forming an immensely complex network. The tasks performed by each neuron are dependent on molecular structures and mechanisms, but also on their physical position in the brain. Scientists from various disciplines at the Forschungszentrum Jülich (Jülich Research Center), a member of the Helmholtz Association, are working toward understanding these interacting factors using the latest imaging techniques, microanatomy, cell biology, genetics and methods derived from physics and informatics. Their aim is to create a virtual human brain which covers spatial aspects from the molecule right through to the complex functional system. Existing brain maps support the early detection and treatment of neurological and psychiatric diseases.

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## 5 Biomedicine and medical technology



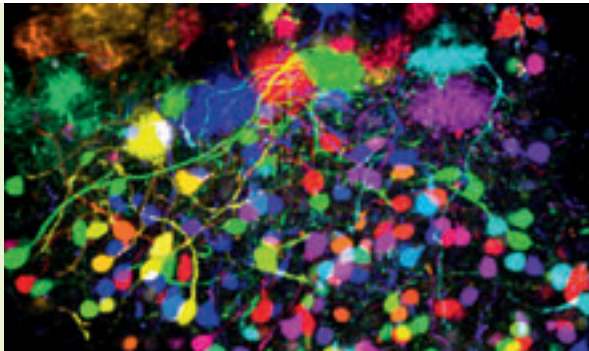
Magnetic resonance imaging (MRI) is used primarily in medical diagnostics.

in both healthy and sick patients and to research how our brain changes over the course of our lives.

MRI enables us to see inside the brain by visualizing structures and tissue types. The stronger the magnetic field which is applied, the more clear and crisp the pictures. In addition, it can also show which areas of the brain are particularly active at any one time and which areas are involved in speech, vision or hearing, for example – this is known as functional magnetic resonance imaging (fMRI). In PET imaging, a weak ra-

dioactive substance – known as a radiotracer – generates the signal. This enables brain activity and metabolic processes to be observed, but also tumor tissue or receptors which are responsible for communication between brain cells. To investigate processes such as these in the brain, there is a need for tailor-made radiotracers.

The combination of PET and MRI in a device such as the Jülich 9.4 MR-PET provides anatomically detailed images of the brain, with simultaneous analysis of the



Brain research

### Molecular physiology of the brain

The human brain is probably the most complex structure which nature has produced. Up to 100 billion neurons and even more glial cells form a complex network which performs extraordinary tasks – such as learning, memory and perception. These functions are controlled and executed by molecules. Modern molecular physiology therefore studies the function of these molecules and their role in larger network systems in the brain. One of the greatest challenges is to apply the findings from this field of research to therapies and diagnostic procedures for psychiatric, neurological and neurodegenerative diseases. The DFG Research Center for Molecular Physiology of the Brain is pursuing this objective with an interdisciplinary research program.

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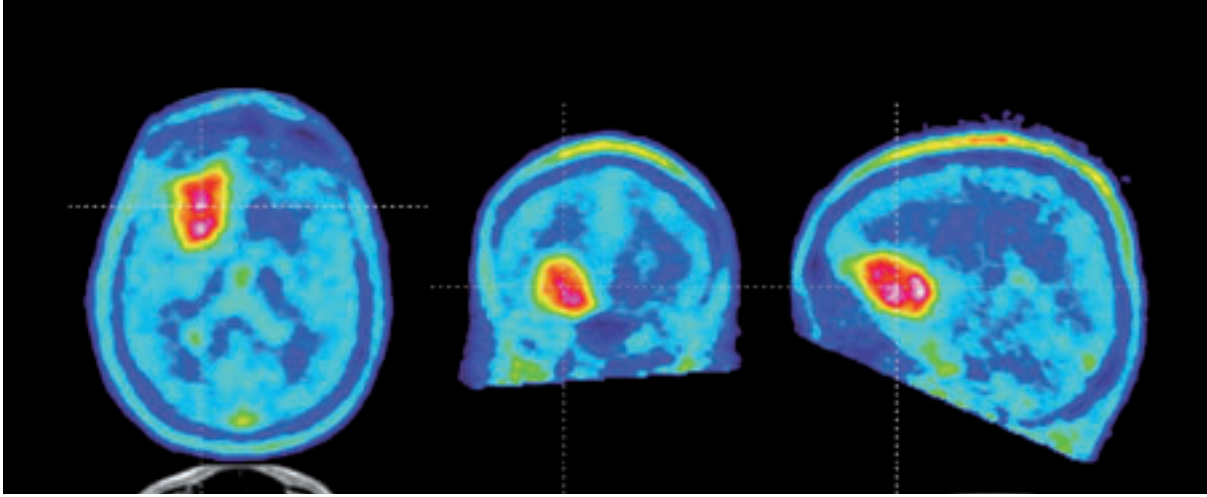
Medical technology

### ORBIT project: the BMBF innovation competition

In complex surgical procedures, simultaneous 3-D X-ray imaging is essential for monitoring the progress and the results of the operation. There is currently no existing system which meets surgeons' needs and is used consistently. Conventional 3-D X-ray imaging systems such as computer tomography are distinctive in that the X-ray source and detector move in a circular path around the patient when recording the image. In the imaging concept designed at the Fraunhofer Institute for Production Systems and Design Technology IPK, the X-ray source only moves around above the operating table. This approach allows a compact, modular system which ensures that the system is capable of mobile use while at the same time guaranteeing unrestricted integration in the operating theater.

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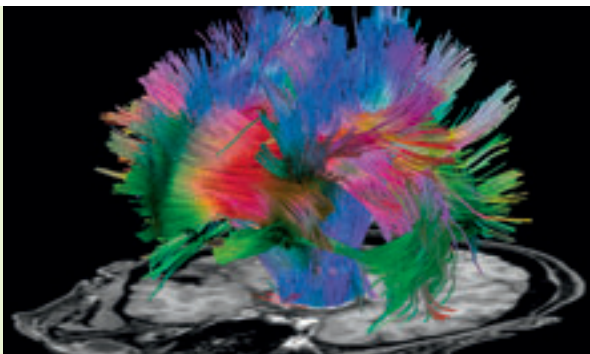


MRI images of a patient with a brain tumor.

activities of different sections of the brain and of the molecular mechanisms and metabolic processes involved. This should make it possible to create customized brain maps for each patient directly from the information about the tasks and functions of the respective region. The scientists also expect to make advances in the study and early diagnosis of neurodegenerative diseases such as epilepsy, stroke, Alzheimer's disease and multiple sclerosis.

## Medical technology for diagnosis and therapy

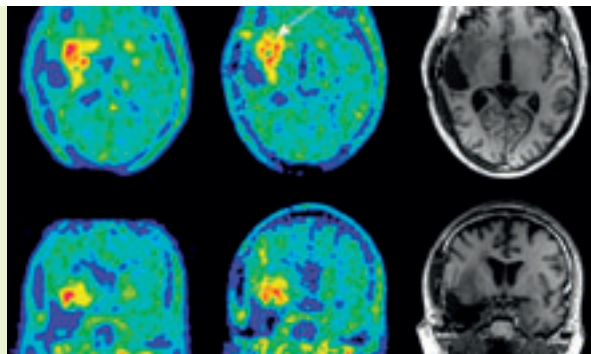
Medical technology is an interdisciplinary technology spanning medical physics, biomedical engineering and bioinformatics. The achievements of medical technology are one of the most important foundations for the progress of modern medicine. They contribute significantly towards improving the prevention, diagnosis and treatment of diseases as well as towards maintaining and restoring health.



Brain research  
**A view of the brain**

Each of the up to 100 billion neurons in the human brain is in contact with nearly 10,000 other cells – no other organ has such a complex structure. Scientists at the Max Planck Institute for Biophysical Chemistry are analyzing the structure and processes in the brain using magnetic resonance imaging. They are developing enhanced imaging techniques and methods for image processing which they are using to study the relationships between the areas of the brain. Local changes in nerve fibers in diseases such as multiple sclerosis or schizophrenia thus become visible. The new methods can also be used to decipher the role of individual areas in the brain in processing information and in decision-making processes.

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Brain research  
**Into the future with 9point4**

An insight into the human brain – without anesthesia or surgery, but in greater detail than ever before. At Forschungszentrum Jülich, within the Helmholtz Association, there is a device for this which is the only one of its kind in the world: a 9.4-tesla magnetic resonance imaging (MRI) scanner, combined with a positron emission tomograph (PET). The hybrid device produces images of the tissue in the human brain (MRI) and is at the same time able to show the metabolism in cells using a weak radioactive substance (PET). This allows the structure and function of the brain to be analyzed simultaneously, right down to the molecular level. This opens up new avenues for research into neurodegenerative disorders such as epilepsy, stroke, Alzheimer's disease and multiple sclerosis. The "9point4" is funded by the German Federal Ministry of Education and Research (BMBF), Siemens, and the Forschungszentrum Jülich.

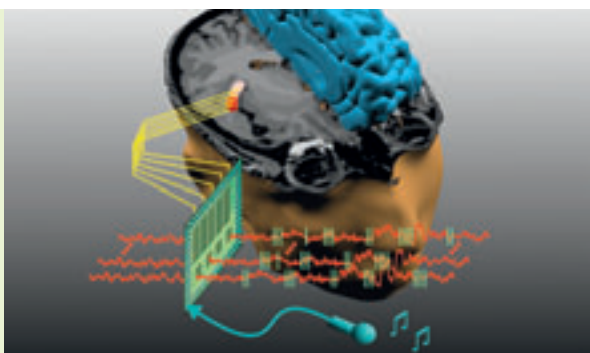
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Advances in medical technology are revolutionizing diagnosis and therapy.



Today there is not a single area of medicine which does not use products or processes from medical technology – from ultrasound methods for prenatal diagnosis and early detection of cancer using imaging techniques or of stenoses in coronary vessels using catheter techniques at one end of the spectrum, to laparoscopic operations, transplantation medicine, implantology and prosthetics, right through to the highly-complex technologies used in intensive care medicine, to name just a few fields of application.

Medical technology leads to improvements in quality of life – we need only think of the developments in the field of vision aids and hearing aids or the restoration of mobility using artificial joints. The most recent advances in the field of brain pacemakers, which can allow patients with Parkinson's disease to return to a virtually normal life, are striking. Medical technology also plays a substantial role in the life expectancy of people, which is increasing to this day – firstly indirectly as a result of the numerous preventive measures, but in particular due to the development of effective and low-risk diagnostic and therapeutic processes.

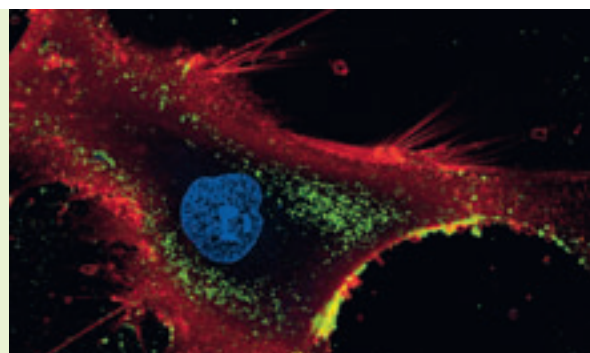


Brain research

### Neuroprosthetics and deep-brain stimulation

The language of neurons is bioelectricity. Memories, emotions and sensations occur in the brain as a result of complex patterns of electrical excitation. Many brain disorders such as Parkinson's or epilepsy go hand in hand with disturbances in these excitation patterns. At the Leibniz Institute for Neurobiology in Magdeburg, electrical stimuli are being used to bypass areas of the brain with functional damage with the help of deep-brain stimulation. Interactive neuroprostheses can use feedback to adapt to current activity states in the brain and can therefore synchronize the timing of the electrical stimulation extremely precisely with the brain activity. Records from the deep-brain stimulation are also used to successfully treat therapy-resistant addictions.

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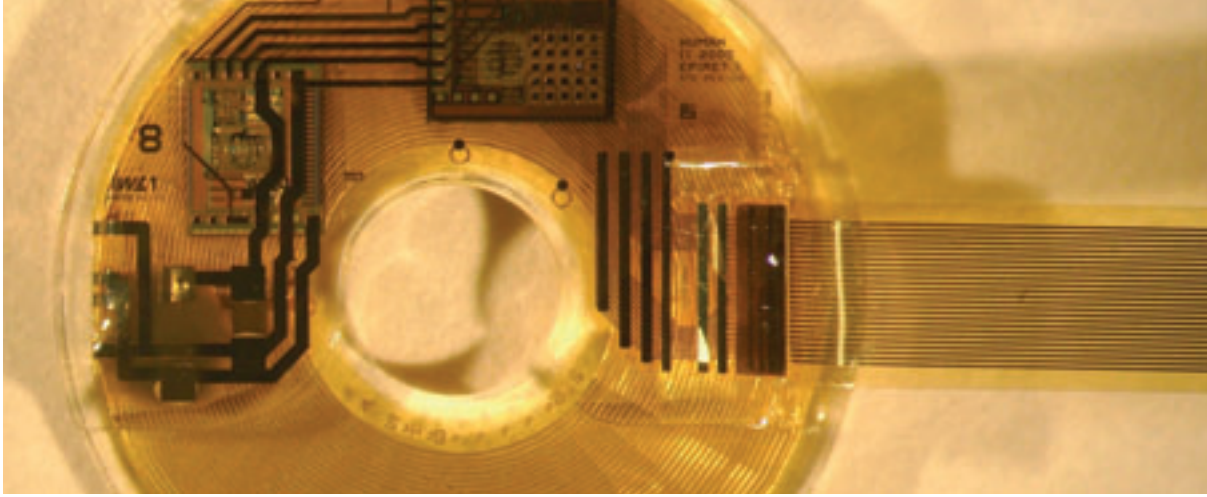


Nanomedical technology

### Nanocarriers in medicine

Nanoparticles contain more than meets the eye – in the truest sense of the word. These structures, which are just a few thousandths of a millimeter across, can be used as tiny transport containers. Nanoparticles are so small that they even penetrate into cells and their nuclei without damaging them. At the Max Planck Institute for Polymer Research, scientists are working on methods that can be used to produce nanospheres and nanocapsules for the diagnosis and treatment of diseases. They have developed nanocapsules with a built-in release mechanism in which a wide variety of substances can be stored. Mini carriers such as these could in future be used to transport drugs to their exact target location or could be used as magnetic probes to make tumors visible.

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**An implantable and wireless visual prosthesis.**

Looking at the example of breast cancer alone, one of the most common of all cancer types, the progress made by medical technology can be seen in the increased recovery rates: new and improved imaging techniques have increased the 5-year survival rate by about 10 percent within the last 20 years.

It is difficult to overestimate the significance of medical technology for the entire health system. Age structure and spiraling costs are key problems for the health system, and medical technology contributes significantly towards solving them. In industrialized countries, the

over-55s age group is growing by 25 percent every 5 years, which means that polymorbidity and age-related illnesses are placing an increasing strain on the health system. Medical technology opens up numerous possibilities here, for example by shortening the duration of inpatient treatment during minimally invasive surgical techniques in order to help reduce the strain on the health budget. Laparoscopic procedures allow the length of hospital stays to be reduced by an average of 50 percent, which corresponds to a potential saving of more than half a billion euros.

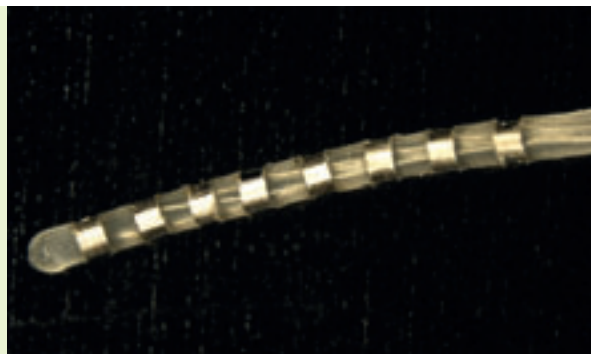


Cardiovascular research

### **Physiological regulation of the heart**

In the case of advanced cardiac insufficiency which is no longer responsive to treatment with medication, it becomes necessary for the patient to have a heart transplant. If no suitable organ is available, circulation must be maintained by a mechanical support system or a fully artificial heart. In order to achieve adequate perfusion of the organs even when physiological demand fluctuates, the pumping capacity must automatically adjust to different body conditions and requirements, such as climbing stairs and high external temperature. As part of the "Heart Control" project, the feasibility of this kind of regulation is being studied in detail and tested on the basis of support and heart-replacement systems developed at the Helmholtz Institute at RWTH Aachen University.

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Medical materials

### **Implants for the future**

The Collaborative Research Center 599 is devoted to current issues relating to medical implants from the fields of ear, nose and throat medicine, orthopedics, trauma surgery, dentistry and cardiac surgery. The CRC 599 focuses on metallic and ceramic materials and pursues a variety of innovative approaches to improving the properties of implants. One aspect of the research looks at the increase in biofunctionality and biointegration as a result of programmed interaction of the implant with the tissue. In this way, the implant can be optimally adapted to the respective application site in the body. To this end, physical, chemical, biochemical and biological methods for assigning functions to implant surfaces are being developed in various sub-projects.

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Miniaturized treatment and surgical procedures reduce the stress for patients.

Medical technology accounts for only around 4 percent of Germany's national health budget, and even if maintenance and follow-up costs are taken into account this figure is still less than 10 percent. Ultimately, the economic importance of the medical technology industry must not be underestimated. The fact that 25 percent of all revenues are derived comes from products which are less than two years old speaks for the innovative strength of the medical technology industry. Germany is placed third in the global medical technology market with an 8-percent share, behind the USA (40 percent)

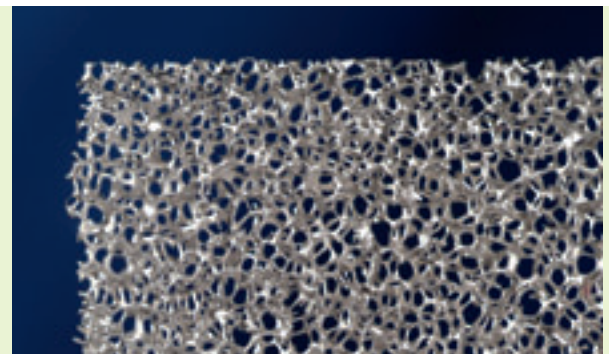
and Japan (15 percent). According to surveys by the German Research Foundation (DFG) and the German Federal Ministry of Education and Research (BMBF), rehabilitation, imaging and regenerative medicine are areas of medical technology with a promising future. One particular problem for the future is the shortage of young people studying courses in medical technology. The DFG's "Early Career Academy in Medical Technology" program has become a trendsetter in this area.



Biomedical, chemical and pharmaceutical technology  
**The German Jordanian University, Amman**

The German Jordanian University (GJU) in Amman has been training biomedical and chemical-pharmaceutical engineers since 2005. The project is funded by the German Academic Exchange Service (DAAD). The two English-language Bachelor degree programs have been running for five years and are based on the curricula at German partner universities. All students spend one year in Germany, half of which is spent on placement with a German company and the other half of which is spent studying at one of the German partner universities.

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Medical materials  
**Metallic foam structures as a bone substitute**

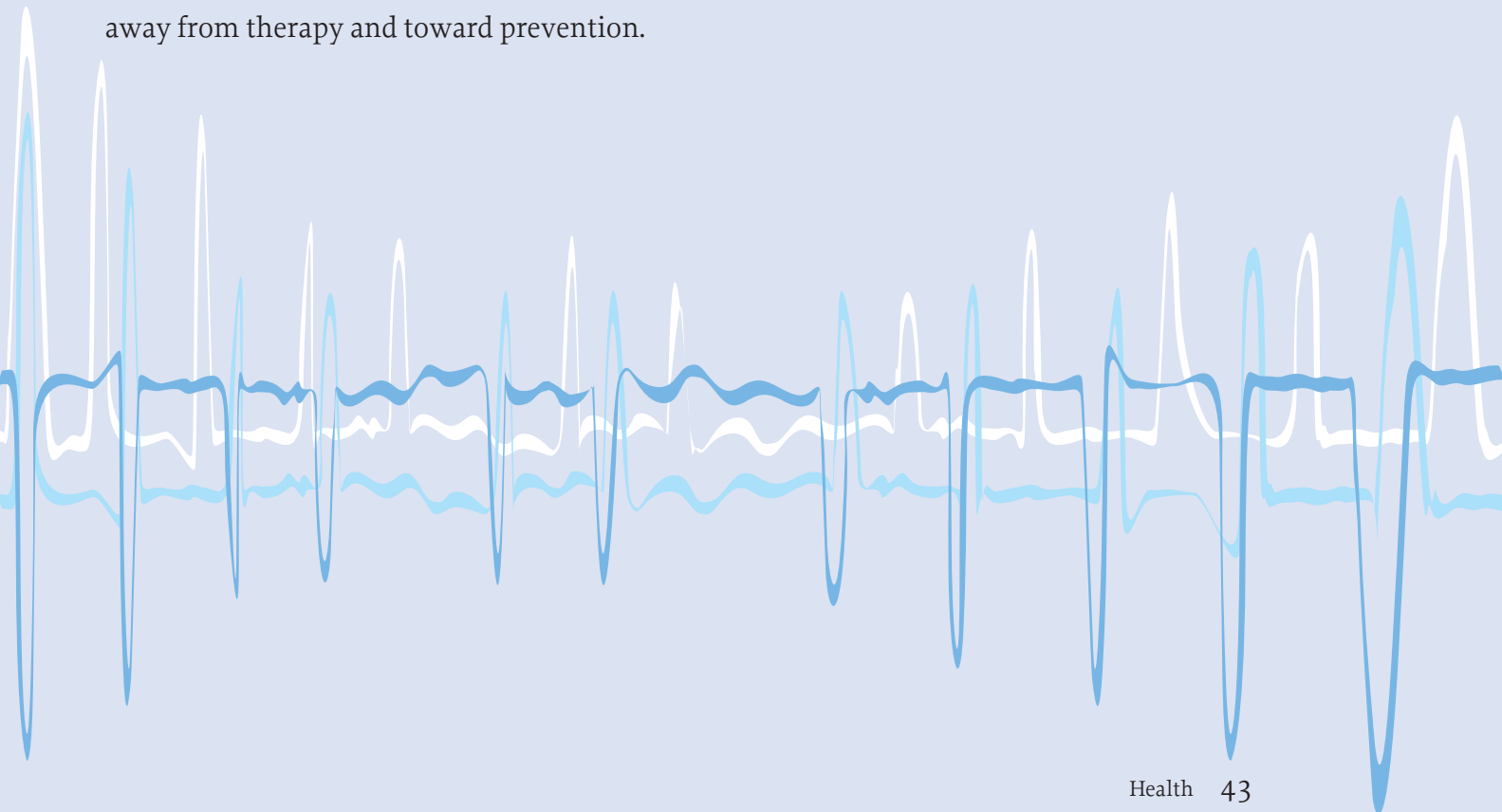
Until now, solid implants made from titanium alloy have been used in trauma surgery. The material is durable and is well tolerated by the body. However, these implants are significantly more rigid than the surrounding bone, which disrupts the formation of new bone and may lead to bone degeneration. In an interdisciplinary project, the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Dresden is developing a new generation of implants which are very similar to the foam-like structure of the substance inside bones. The focus of the work is on open-cell titanium foams, which have bone-like mechanical properties and allow the ingrowth of bone cells and blood vessels, which are necessary for bone growth.

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## Focusing on the patient

Our health system ought actually to have a different name: the ill-health system. When it comes to disease control, traditional medicine far too often waits for a condition to develop – in many cases until it is barely treatable or no longer treatable at all. The only real way out of this ingrained situation involves a radical rethink of medical practice and research: away from therapy and toward prevention.



## 6 Sustainable health services research



**Patient protection also includes data protection.**

This about-turn in health policy can only succeed if a large number of parameters are adjusted. This includes a change in the behavior patterns of the general public, who must view their health as a competence and should visit their doctor regularly when they are healthy; of the health insurance funds which finance these visits and which should also focus on health rather than ill health; and last but not least of doctors who, instead of dealing with sick patients, will be required to lend advice to healthy people, which means identifying

the development of diseases at an early stage and taking preventive action.

Another aspect of patient care must also be taken into account, namely that of data protection. Insurance funds, doctors and hospitals – the channels through which patient data is gathered – are faced with a very tricky situation, because on the one hand they need to exchange data in order to provide patients with the best possible care. On the other hand, if it falls into the



Rheumatology research

### **Caring for patients with rheumatological disorders**

In the last ten years, the field of rheumatology has seen innovations in therapy which have resulted in lasting changes to healthcare practice: virtually every year, a new and effective drug has entered the market. With the assistance of rheumatologists from all over Germany, a working group at the German Rheumatism Research Center in Berlin has been studying the care provided since 1993. Each year around 17,000 patients with inflammatory rheumatic diseases are recorded in a standardized way. This enables trends in the care provided to be analyzed and also contributes towards quality assurance. Each participating institution receives an analysis of its own data compared to institutions with similar structures and in the same general situation.

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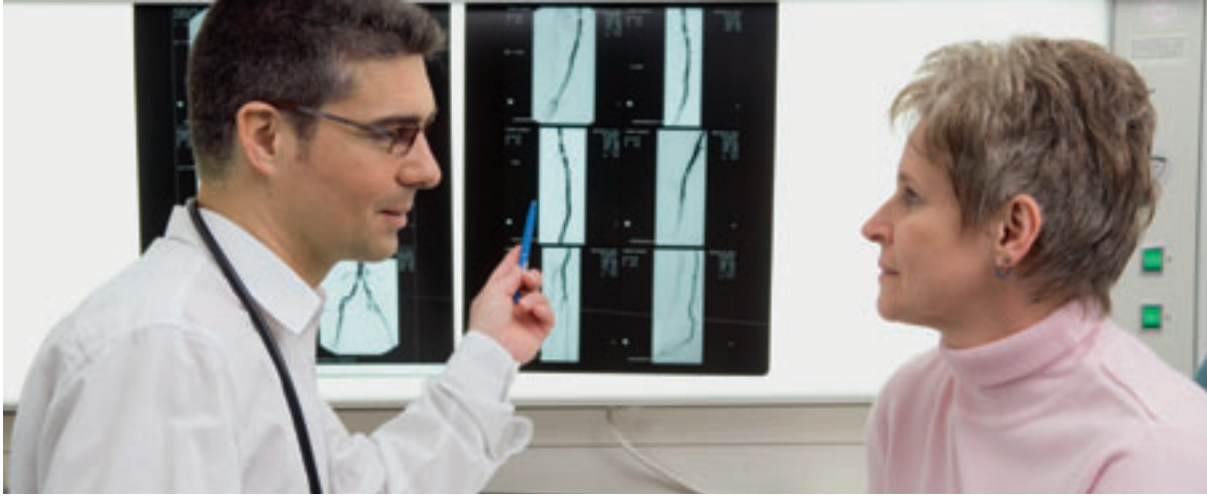


Health services research

### **The DFG youth academy**

November 2010 saw the launch of the newly-established “Early Career Academy in Health Services Research” set up by the German Research Foundation (DFG). The aim of the academy is to support talented young scientists with an interest in issues relating to health services research at an early stage in their career. The academy provides scientists from a variety of different disciplines with the opportunity to obtain an overview of the broad spectrum of health services research, to develop their own study, to identify pitfalls and shortcomings in research proposals and in the design of studies into health services, and ultimately to promote development in the field of health services research.

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**A relationship of trust between doctor and patient is a prerequisite for successful treatment.**

wrong hands, medical data can easily be abused, for example in the workplace or by insurance companies. Economics, data protection, research – it seems that health cannot be dealt with by one government department alone. The health economics problem which faces us is of dramatic proportions. It can only be overcome with a radical change in thinking and through political will. This applies in particular to the Ministry of Finance, which needs to recognize that expenditure on health research must not be regarded merely as

consumer spending issue but rather as an investment, namely an investment in the future of a nation. A nation of sick people is not something to celebrate – the HIV drama played out in some African countries shows how serious a threat a single infectious disease can pose to a nation's existence.

One way or another, the focus of research and of the "health executives" must shift more towards the patient.



Health policy  
**Health as a global problem**

Global health policy has existed for more than a hundred years, but it has changed radically. Rapid globalization is a contributing factor in this. The focus is on local healthcare provision and the global spread of disease. Hundreds of organizations generate a chaotic variety of activities. As a result, the coordinating role of an international organization such as the WHO remains indispensable. The integration of a global civil society is necessary for the mobilization of resources and for the general acceptance of international rules and guidelines for improving world health. Researchers at the GIGA German Institute of Global and Area Studies are studying the institutional change of global health governance.

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Health policy  
**Center for International Health (CIH)**

The project is one of five think-tanks which form part of the DAAD program "exceed – Higher Education Excellence in Development Cooperation" and is funded by the German Federal Ministry for Economic Cooperation and Development. The center at the Ludwig-Maximilians-Universität in Munich (LMU) and its international partners are working on health problems in developing countries at a number of levels: research, education and development of policy solutions. The aim is to enable the partner universities to define the content of their own education and research, to integrate themselves into international knowledge networks, to implement their research findings and to give expert advice to policymakers.

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**The Alliance of Scientific Organizations is an amalgamation of major German research organizations. The partners involved take on the lead management function on a rotating basis. The Alliance includes:**

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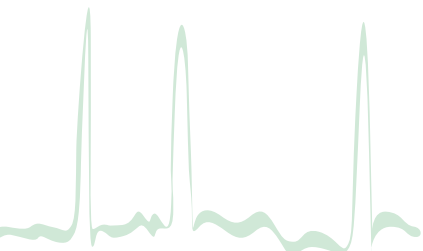
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