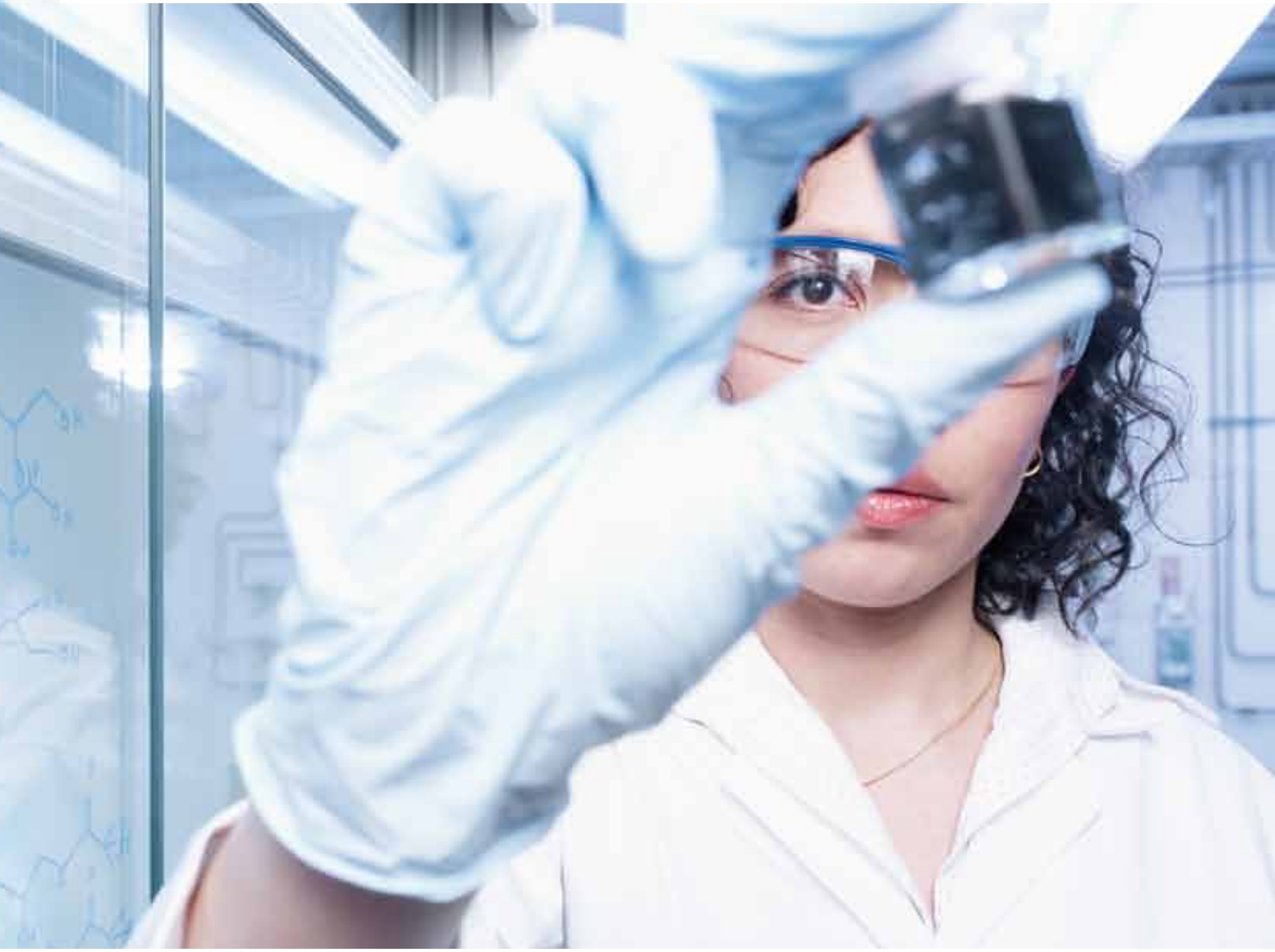
MATERIALS RESEARCH I COASTAL RESEARCH

Science creates benefits



Helmholtz-Zentrum Geesthacht

Centre for Materials and Coastal Research

Prof. Dr. Wolfgang Kaysser and Dipl. Ing. Michael Ganß

Preamble

Dear Readers,

The advent of the Internet, the automobile, or indeed industrialization in general, have brought dramatic changes to our society over the years. Today we are facing new global challenges. What does the future hold with regard to energy supplies? How can we overcome the dangers posed by climate change? And how can we harness medical science to respond to demographic developments? Researchers at our centre are engaged in the development of concepts which aim to find the answers to these pressing issues.

Mobility, energy, climate change – as a simple glance at the determining issues of our times clearly shows; neither the problems specific to the North German region nor wider global issues can be solved without the contributions made by research scientists. Not only politicians and representatives of business communities, but also many normal citizens require professional expertise and seek sound scientific advice. We, therefore, feel a particular commitment towards them when we say: Use the Benefits of Science.

Our motto is, however, open to a different interpretation: Knowledge Generates Uses. This is what we do, each day anew, with great dedication and a desire to serve society. Nonetheless, science is hard work which goes beyond the normal call of duty. Good research often requires staying power. Decades may pass before the initial idea is transformed into a successful application.

We are using this opportunity to introduce our scientific endeavours to you and invite you to use this brochure to gain knowledge.

We wish you a pleasurable read.

Prof. Dr. Wolfgang Kaysser
Scientific Director

Dipl. Ing. Michael Ganß
Administrative Director

Contents

Who we are

The Helmholtz-Zentrum Geesthacht is a non-profit making research establishment in the legal form of a limited liability company and one of the 17 members of the Helmholtz Association of German Research Centres.

What drives us

→ the development of new and light materials based on metal or plastics
→ the transfer of new welding techniques for cars and aircraft into industrial applications
→ the exploration of environmentally-friendly energy sources and the consequent reduction of greenhouse gases
→ the development of biomedical materials which promote the regeneration of damaged cells or tissue
→ the identification of past and future developments in the climate and in coastal areas
→ the protection of coastal areas worldwide

We want to drive things on

The following pages will give you an insight into our motives and the achievements and successes of our research.

How we are organised

Associates
The Federal Republic of Germany, the federal states of Schleswig-Holstein, Free and Hanseatic City of Hamburg, Lower Saxony and Brandenburg and various private commercial enterprises.

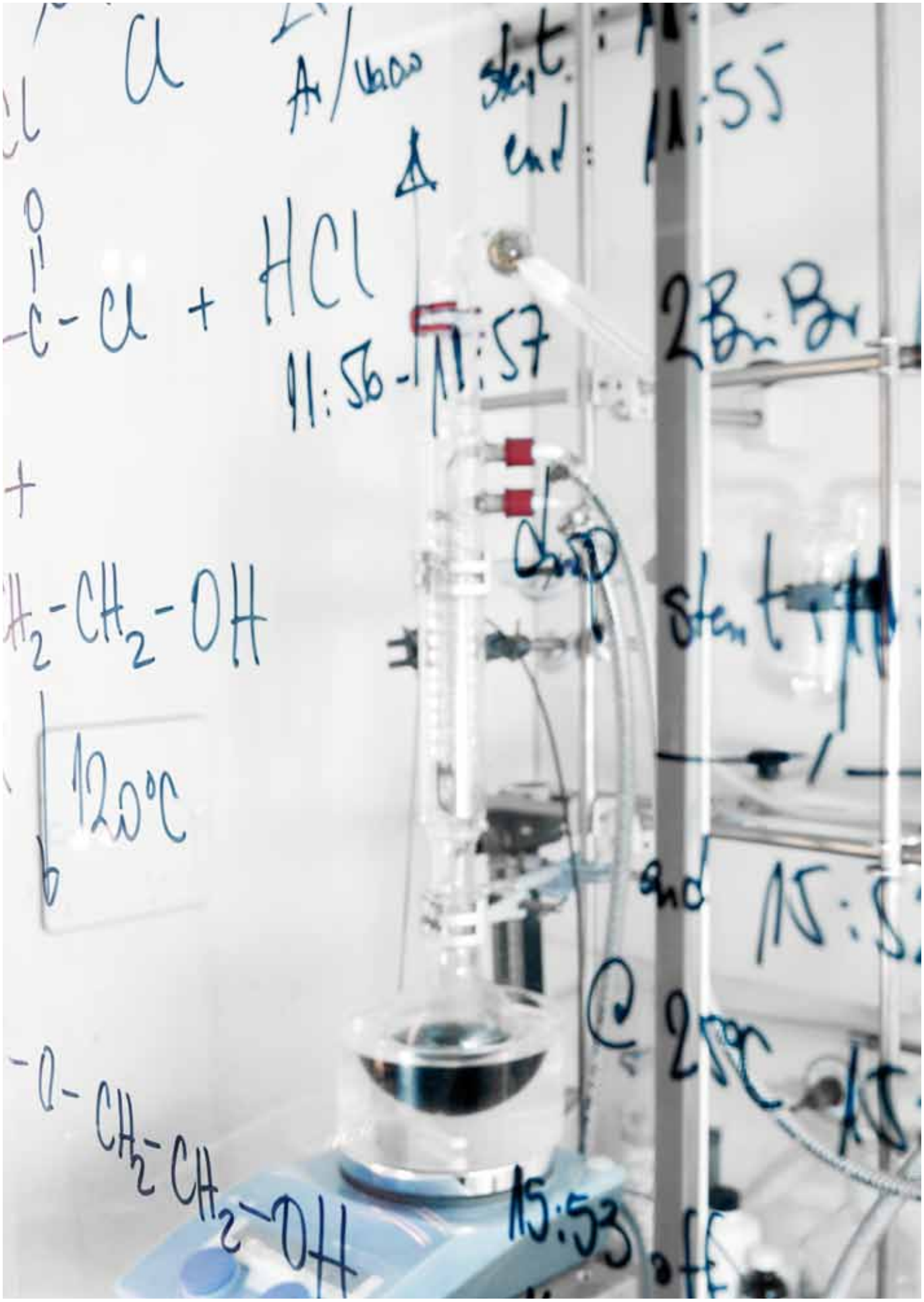
History
The Centre was founded in Geesthacht on 18th April 1956 as the GKSS (Society for the Utilisation of Atomic Energy in Shipbuilding and Shipping Ltd.). In the course of time our research topics have moved towards materials research and coastal research. In November 2010 we have therefore been renamed in Helmholtz-Zentrum Geesthacht, Centre for materials and coastal research.

Total Budget
Approximately 80 million euro

Number of employees
More than 850

Scientific Institutions
→ Institute of Materials Research
→ Institute of Polymer Research
→ Institute of Coastal Research

Sites and Outstations
Geesthacht: Headquarters // Teltow: Centre for Biomaterial Development // Berlin: Berlin-Brandenburg Centre for Regenerative Therapies // Hamburg: The German Electron Synchrotron DESY, Climate Service Centre CSC // Munich: The Neutron Source Heinz Maier Leibnitz at the Garching Campus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Institute of Materials Research

Climate-friendly and environmentally-friendly technologies in the areas of mobility and energy will be an integral part of our future lives. Through our research, we wish to promote reconciliation between the interests of the economy and ecology. //

Prof. Dr. Karl Ulrich Kainer, Spokesman for the Directors of the Institute of Materials Research

In future, our climate will be partially determined by the volume of greenhouse gas emitted into the atmosphere. This problem can be illustrated with a simple calculation. On average, a car creates 170 grams CO_2 per kilometre. In Germany more than 41 million people drive cars. If these are driven a mere one kilometre a day, this amounts to around seven million tons of CO_2. How can energy be saved and CO_2 emissions reduced in the world of today? Hightech materials, effectively processed and applied, can make our world a better place. New materials and techniques create lighter, safer cars and aircraft, or pave the way for technologies which create more environmentally-friendly energy supplies. Fuel consumption can be lowered with the aid of lightweight constructions. Natural energy resources are thus conserved and greenhouse gas emissions reduced.

Scientists at the Geesthacht Institute of Materials Research are engaged in the development of new light-weight structural materials for a wide range of applications. Their alloys are utilized, for example, in the construction of cars and aircraft. Some materials, in the form of micro-milled metal powders, are being investigated by the scientists with regard to their potential for hydrogen storage. Nowadays, tailored materials and processes are frequently developed with the aid of computer simulations. It is also essential to have advanced measuring methods regarding the internal structure of the materials down to the level of the atom. Materials development, therefore, remains a long and time-consuming process, demanding a great deal of experience, scientific creativity and patience. If the material proves to be promising, numerous series of tests will subsequently be carried out. Industrial implementation only follows when there is a guarantee that the development is one hundred percent safe under real conditions; for example, the utilisation of a weld or hightech material in an aircraft.

Materials research scientists in Geesthacht profit from the special way in which the centre is structured. Internationally renowned experts collaborate on projects; from the initial idea through to the processing and testing of complex components under realistic conditions.

The particular strength of the Geesthacht materials researchers lies in this unique cooperation.

Institute of Materials Research

→ Approximately 180 employees
→ 4 Institute Directors
→ Outstations: Hamburg, Munich

Preparation of minute samples:
New materials are tested in the Geesthacht Nano Laboratory.

Three questions to Prof. Dr. Ing. Karl Ulrich Kainer

Spokesman for the Directors of the Institute of Materials Research,

Head of the Magnesium Innovation Center MagIC

What are the main fields of research at the Institute of Materials Research?

→ We develop materials, processes and technologies in the field of lightweight construction, in particular for motor vehicles and aircraft. Our new welding process reduces the number of rivets or screws required, and thus makes aircraft lighter. One of our particular strengths lies in the testing of these developments, whereby we can examine the behaviour of components from the atomic level up to complex components. We operate research facilities which are internationally unique and which enable the non-destructive testing of materials and components, for example with X-ray techniques.

What do Geesthacht materials scientists do?

→ We work in close cooperation with users. We want our research to support the development of environmentally-friendly technologies which can be speedily taken up by industry. This can range from an aluminium metal sheet for vehicle construction to a hydrogen tank with storage materials based on metal powder. However, many areas are still at the development stage. This is what makes our research so stimulating and exciting.

What is the special emphasis of your research developments?

→ We create national and international networks with other scientists and also work in close cooperation with industry. The transfer of research results into technical and economic applications is speeded up considerably due to this interdisciplinary cooperation.

Our new welding processes can reduce the use of rivets and make aircraft lighter.

At the magnesium casting oven: Geesthacht researchers examine many processing areas, from the molten mass to the investigation of surface characteristics.

Geesthacht scientists develop new materials and technologies for lightweight construction.

Focuses of Research

Ultralight and extremely resilient

Research scientists in Geesthacht have developed an extremely light titanium-aluminium alloy. These ultralight materials are exposed to high operating temperatures in motors, turbines or engines. The titanium aluminide alloy, developed in Geesthacht, can withstand temperatures of up to 750 degrees centigrade, yet is much lighter than the nickel alloy conventionally used. Turbine blades made of titanium aluminide are used today in aircraft turbines, for example. The weight of these components is thereby reduced by approximately half.

Light material with strong potential

Magnesium makes cars and aircraft lighter. These subsequently use less fuel. Magnesium is already being utilised in the production of steering wheels, gearboxes, fittings and seats. It is about a third lighter than aluminium, yet just as robust – an ideal prerequisite for light construction. But how does the sheet metal behave in the case of an accident? What can be done to avoid possible corrosion? The Magnesium Innovations Centre is a globally unique research platform for the field of magnesium and can provide the answers to these questions.

Researchers at the MagIC centre pursue an integrated approach. They develop new alloys, create tailored material properties, improve manufacturing processes and thereby establish the basis for subsequent industrial implementation.

Technology creates connections

The fuselage of modern aircraft consists of a mix of aluminium- and fibre-reinforced composite structures which are often lighter and more durable than pure metal structures. Conventional welding processes, such as the riveting of sheet metal are not optimally effective for the new methods of construction. They can be replaced with special weight-reducing welding techniques. But can plastics also be reliably and safely connected to metal without adhesives? In Geesthacht they can. The research scientists have developed and patented new processes in which aluminium, magnesium and fibre-reinforced plastics can be welded together – and this completely without smelting or the creation of sparks or vapours. The materials are simply firmly connected to each other by means of friction.

Storing Hydrogen

Hydrogen can be our energy source of the future. However, there are still many unsolved issues. One being: How can hydrogen be safely and efficiently stored? One possibility is storage tanks on a metal hydride basis. The gaseous hydrogen hereby forms a reversible chemical bond with defined metal alloys. Geesthacht scientists are front-runners worldwide in the development of these nano-structured metal powders. In order to implement hydrogen storage in industrial applications, they are working on improvements for loading and unloading times of the metals, developing an economic production technology for the alloy powders and solving the issues involved in ensuring safe storage in tanks.

Bio-implants made of magnesium

Research and development in the field of titanium or magnesium-based metallic biomaterials has been carried out in Geesthacht for some time. Implants made of the light metal magnesium, support bone regeneration and biodegrade in the body after a defined period of time. Magnesium is a natural component of the body and therefore particularly well tolerated. Moreover, the material is strong, yet at the same time elastic. This means that it can be customised to meet particular skeletal requirements.

Interdisciplinary Platform ACE

The “Lightweight Materials Assessment, Computing and Engineering Centre” (ACE) is presently being set up in order to speed up the flow of new lightweight construction materials and technologies into innovations. Its strength lies in the combination of processing, characterisation and simulation methods. The objective is the development of significantly more efficient lightweight structures; from the initial conception to the production of prototype components through to the testing stage. Shock absorber elements for cars or welded segments for aircraft are highly-complex and their development is very time-consuming and costly. This can be achieved more speedily and, above all, more cost-effectively with the combined research system of the ACE.

Does the new material hold true to its promise? Is the welding joint break-proof? How does the inner structure of the material change when subject to load? Scientists have a wide variety of instruments at their disposal for use in their test series. At the Institute of Materials Research, scientists from diverse fields, e. g. mathematicians, physicists and engineers, research and characterize new materials or develop methods for economic processing and manufacturing. Material testing is of key importance in this, as: Safety is Paramount.

Current Research

Solving material problems with super microscopes

A deep look into the weld seam – in order to achieve this our research scientists use neutrons or a particularly intensive X-ray, so-called synchrotron radiation. Neutrons and synchrotron radiation beams penetrate deep into the material, thus enabling observations on the structural properties within components, materials, and biological systems. Scientists work at their own measuring stations at the German Electron Synchrotron (DESY) in Hamburg and at the Munich Research Reactor (FRM II) in Garching.

At the beamlines in Hamburg, X-ray light is used, for example, to carry out investigations into the inner stresses which have arisen in a work piece during the manufacturing process. Particularly high resolution i. e. very detailed images, are taken by means of micro- and nano-tomography for various other purposes. The intensive synchrotron radiation enables particularly fast measurements, for example, during the welding process.

In Garching near Munich, researchers operate beamlines with which mechanical stress and texture properties in materials can be measured. Particularly large components can be analysed with the aid of this neutron viewing. The Helmholtz-Zentrum in Geesthacht bundles its activities in the field of synchrotron radiation and neutrons at the “German Engineering Materials Science Centre” (GEMS). The exceptional research instruments are available for the use of external researchers.

A view of the nano cosmos

The heart of the Geesthacht nano laboratory is the dual beam microscope; a high performance microscope with which samples can be investigated at nanoscale level. It consists of a high resolution electron microscope which can be combined with an ion beam. This equipment is used, in particular, for the preparation of minute samples for mechanical testing. Deformation and damage processes can hereby be studied at the crystal level of the new material. This data flows directly into the development of computer models and serves to optimize manufacturing processes.

Using Magnesium like aluminium

New magnesium alloys are being developed in such a way that they possess the same strength as aluminium alloys but are even lighter. In order to achieve this, research scientists must closely observe all the parameters and the effects of the alloying elements during the casting and solidification processes. A casting and rolling technology for magnesium sheets has been further developed for this purpose and new alloys have been prepared and adapted specifically for this procedure.

Left: Must be one hundred percent dust-free – the chamber in which the light beam is prepared for the experiments.

Right: Requires particularly precise setting – a researcher at the diffractometer experimental facility at the German Electron Synchrotron.

Below: Special welding for lightweight construction is developed in Geesthacht. See here: Friction Surfacing.

Institute of Polymer Research

The use of nanotechnology in membranes or other polymer materials will lead to the creation of exceptional products with totally new characteristics in the near future. //

Prof. Dr. Volker Abetz, Director of the "Centre for Membranes and Structured Materials"

The use of polymer materials in clinics presupposes their purity and tolerance. We will, therefore, continue to synthesize and process under strict GMP conditions in the future. //

Prof. Dr. Andreas Lendlein, Director of the "Centre for Biomaterial Development"

Polymer materials, better known as plastics, are familiar to everyone in everyday life. They are present in vehicles, in electronic components, in packaging, in protective and insulating coatings, in the world of medicine and in diverse other applications. In Geesthacht and at the Teltow location near Berlin, scientists are engaged in research on the synthesis, analysis, testing, design and processing of plastic materials. Research in the field of biomaterials, which is being carried out in Teltow, also includes comprehensive tests on cell tolerance and toxicity.

These engineers, physicists and chemists are developing polymers with entirely new functions. Some of the materials created have totally unsual properties. Modern plastics can, for example, make cars lighter or, as tailored membranes, separate diverse substances. They are even suitable for implants in regenerative medicine.

Progress is being made in the field of biomedical materials in the "Innovation Nucleus Biomedical Materials Berlin-Brandenburg" at the Teltow location. Biomaterials are synthetic and natural materials, which are used to replace or repair body tissue, and for diagnostic purposes. Researchers endow the innovative biomaterials with specific functions such as, for example, a shape memory or the ability to release active molecules into the body in a controlled manner.

The potential of plastic design had already been realised in the past. One of the success stories of the Geesthacht polymer research scientists was the creation of special membranes for the recovery of petrol vapours. They are utilised to reduce the toxic fumes which arise during refuelling operations. The system was developed in Geesthacht in the eighties and is now in use worldwide. 60 percent of all fuel terminals in Germany have petrol vapour recovery systems based on this membrane technique.

The hightech membranes of the future will be made of polymers which both separate efficiently and have high permeability i. e. the new membranes will work selectively, only allowing the correct substances through. The special feature of the Geesthacht membranes: they do this extremely quickly. Geesthacht research scientists are developing membranes with uniform pore size for applications in biotechnology. They could be utilised in future to filter the very smallest particles, such as proteins.

Institute of Polymer Research

- → 160 employees
- → 2 Institute Directors
- → 2 locations: the "Centre for Membrane and Structured Materials" in Geesthacht and the "Centre for Biomaterial Development" in Teltow, near Berlin

Continuation of a success story:
Modern plastics with tailored properties are produced in Geesthacht.

Three questions to Prof. Dr. Volker Abetz

Director of the “Centre for Membranes and Structured Materials”

What significance does Polymer Research have for Germany?

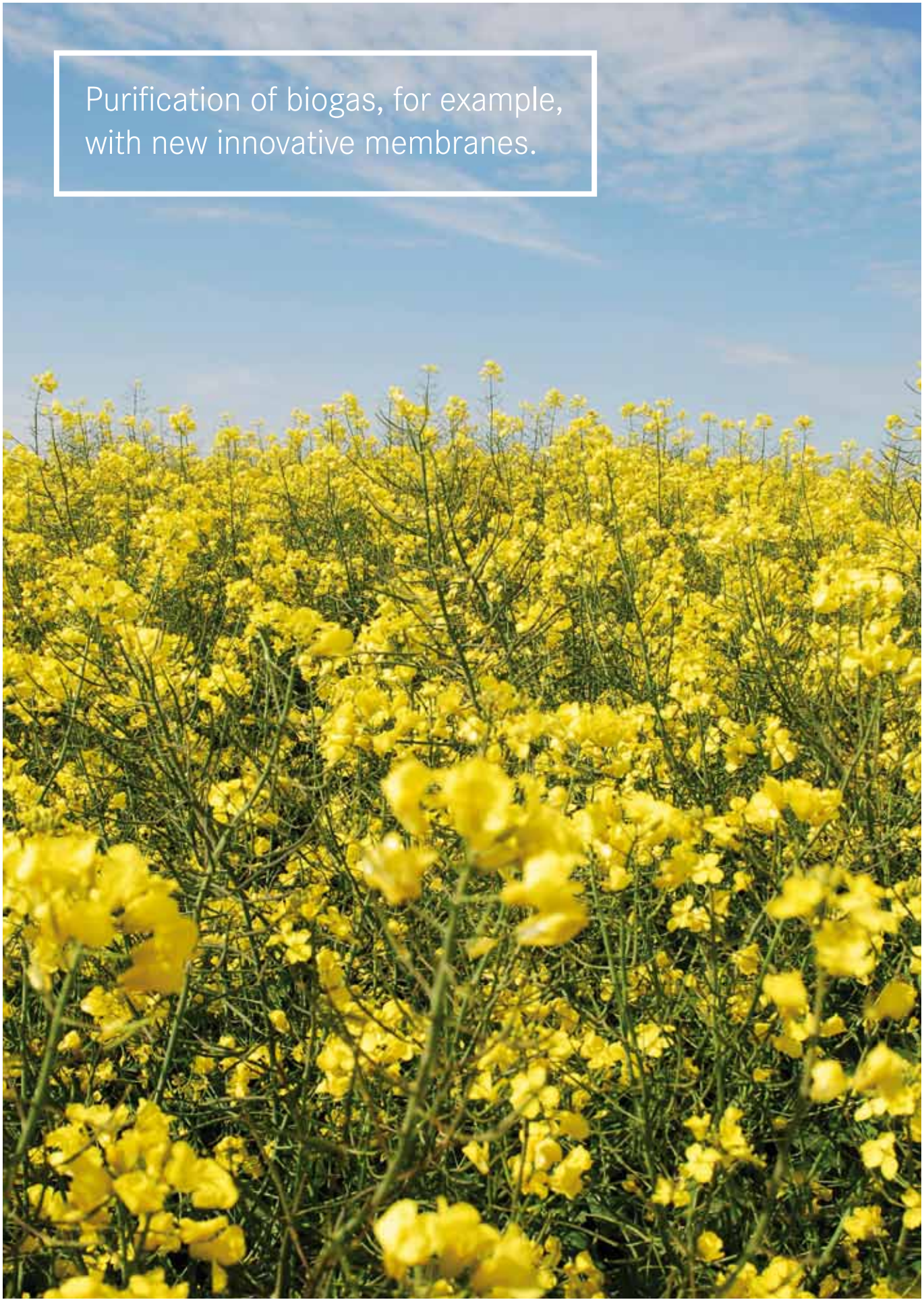
→ Polymer science is most certainly making a significant contribution to future material concepts. The plastics processing industry of today is already one of the major business sectors in Germany, with an annual turnover of approximately 54 billion euro and more than 290,000 employees.

Plastics play a central role, from nanotechnology to processing technology – why is this?

→ Polymers are an ideal option as they can be flexibly adapted and are generally very economical in their application. Meanwhile there are also new techniques for the production of competitive composites e. g. from metal and plastic.

What will your new polymer materials achieve?

→ We will develop new materials on the basis of nano composite materials which are lighter in comparison to metals and ceramics, with the aim of increasing both the rigidity and the toughness. This is crucial for their subsequent application as structural materials. Our innovative membranes with tailored and partially also “switchable” separating properties will provide important impulses for process technology in the chemical industry and in the field of biotechnology, as they are the key to gentle purification procedures.


Purification of biogas, for example,
with new innovative membranes.

Developed in Geesthacht:

Plastic composite materials and carbon nanotubes.

Carbon Nanotubes are twenty times stronger than steel, yet as light as aluminium.

Focuses of research in Geesthacht

Nanotubes for lightweight construction

One focus of the research in Geesthacht is the development of hightech plastics with unusual application possibilities: composites (nanocomposites) made of polymer and carbon nanotubes. The carbon nanotubes are twenty times harder than steel and yet as light as aluminium. They can be used in plastics to increase strength, stiffness and break resistance. The new nanocomposites, which conduct electricity and do not become electrostatically charged, can be utilized, for instance, in petrol pipes for cars and for special packaging materials and membranes.

Structural materials are becoming increasingly important fields of application for polymers. In Geesthacht, small filler particles, so-called nanoparticles, are functionalised for this purpose, and are later dispersed throughout a polymeric matrix to improve its mechanical or other properties.

New generation of membranes

Modern polymer membranes are important for air conditioning systems, energy technology and also for economic, resource-efficient processes in chemical process technology. These hightech materials enable a high throughput of gases or fluids with a high level of selectivity. Oxygen, hydrogen or diverse organic liquids can thus be effectively enriched.

As a rule polymers consist of long chains of the same chemical elements. However, the new generations of membranes use plastics which are made up of completely different units. One unit can be hydrophilic – the other water-repellent, for example. The researchers utilise these special characteristics to develop membranes with tailored properties. The advantage: the polymers arrange themselves in a particular direction during production and form regular structures. When applied industrially, this process would, therefore, be extremely economic, yet also efficient. The spectacular new membrane structures form microfine pores totally independently, which could, for example, filter out viruses or proteins from liquids.

Biogas purification with the use of membranes

The biogas market is booming in Germany. One problem facing many biogas plants: the gas is not pure enough to be fed into the normal gas grid. If, for example, organic waste is fermented to generate methane gas, a gaseous mixture is produced which contains up to 40 percent CO_2. This does not actually contribute to an increase in the carbon footprint, as it originates from biomass. However, if the biogas is to be fed into the natural gas grid, the CO_2 must be separated. Research scientists at the Helmholtz-Zentrum Geesthacht are developing membranes and membrane processes which have been specifically created to complete this task successfully.

Three questions to Prof. Dr. Andreas Lendlein

Director of the “Centre for Biomaterial Development”, Teltow

What is the greatest challenge facing biomaterials research today?

→ There is a great demand for innovative biomaterials for new therapy approaches. However, these require special standards of purity and tolerance and have to go through an elaborate authorisation procedure in order to fulfill the requirements for clinical applications. This procedure costs both time and money; in some cases between ten and fifteen years.

How can the development process be improved?

→ In the Berlin-Brandenburg region we work together with industrial enterprises and a research association of the Free University of Berlin and the Federal Institute for Materials Research and Testing. In order to continue to be an attractive cooperation partner, the establishment of a Competence Innovation and Technology Centre is being planned. In 2006 we also participated in the initiation of the Berlin-Brandenburg Centre for Regenerative Therapies which was set up on the Virchow Campus of the Charité.

Which steps are to be taken in the near future?

→ The promotion of young scientists - at present we are building a Biomedical Technology Centre at our site which will create further space for our new laboratories and provide more capacity for teaching and training. Moreover, we are actively involved in the setting up of a joint synthesis laboratory together with the Chinese University of Tianjin. This will lead to numerous exchanges of doctoral students in future and thus to a lively exchange of scientific information.


Polymer-based Materials for new Therapy
Approaches are Part of the Future.

"Centre for Biomaterial Development" in Teltow near Berlin:
Biomedical materials are being developed here for diverse applications in the relatively new field of Regenerative Medicine.

An artificial hip, biodegradable surgical sutures or skin which has been grown on a plastic frame in a laboratory: biomaterials already play an important role in modern medicine. Research scientists in Teltow have specialised in the development of tailored polymer-based biomaterials, which serve as a basis for diverse applications in the field of regerative medicine. Although regenerative Medicine is still at an early stage, the vision of the medicine of tomorrow is spectacular: the stimulation and steering of the regeneration of the body in order to restore the function of diseased and injured cells, tissue or complex organs. Biomaterials replace organs or functions of the human body for a certain period of time i. e. as long as it takes for these to regenerate themselves. Longterm implants which only have a mechanic function are a thing of the past.

Focuses of Research in Teltow

Implant materials are provided for surgical and pharmaceutical applications to assist in the development of special regenerative therapies. Biomaterials are employed in numerous ways in order to temporarily take over bodily functions until the body has regenerated itself. Polymer systems serve as matrices for a controlled release of substances. Multifunctional, active implants, which take on their final shape only after being inserted into the body, are being developed for applications in minimally invasive surgery.

Scaffold for cells

In Teltow, frames or so-called scaffolds are being developed on which cells can grow to form tissues. These plastic frames are, for the most part, biodegradable and will thus decompose in situ. After a certain time the scaffold dissolves in the body in a biocompatible manner. Such biomaterials play a special role in cases of greater damage such as, for example, large or complex bone fractures. The biomaterials being developed in Teltow not only act as a mechanical reinforcement frame but also supply the cells with spatial information. Moreover, they are loaded with certain molecules which transmit growth signals to the cells.

Artificial vessels for the transport of blood

Wherever flowing blood comes into contact with an artificial material there can be undesirable effects, e. g. the deposition of proteins and blood cells, which can lead to the formation of dangerous blood clots. The scientists at Helmholtz are developing polymer blood vessel replacements which take this into account. The surfaces of the artificial blood vessels are modified in such a way that the forming of blood clots is prevented, but the settlement of blood vessel cells is supported.

Intelligent plastics

Shape memory polymers are able to revert to their original shape after a period of deformation. This memory effect can be activated by external stimuli such as, for example, an increase in the ambient temperature. Scientists in Teltow have also succeeded in triggering contact-free deformation, for example, magnetically or light induced. This is of great help in surgery. A thread of “intelligent” plastic can form itself independently into a bow or draw itself tighter. If it can also decompose independently, the necessity of a further operation can be avoided.

Translational approach

Basic research in the field of biomaterials and regenerative medicine must be transferred to clinical applications as quickly as possible. In order to speed up this lengthy process, expertise from different fields such as materials sciences, chemistry, biology, clinical research etc. is bundled and then linked to industrial development. Therapies for clinical applications are developed in the Berlin-Brandenburg Centre for Regenerative Therapies (BCRT) at the Virchow Hospital in Berlin, working in an alliance with the Charité Medical University in Berlin and the Helmholtz Association, which is represented by the “Centre for Biomaterial Development” in Teltow. The Helmholtz-Zentrum Geesthacht has six groups which contribute to this research alliance with their work in the field of regenerative medicine.

Institute of Coastal Research

One thing is certain: our climate is changing - yet there is a great deal of uncertainty about what the consequences will be when rainfall and storm winds increase. //

Prof. Dr. Hans von Storch, Director of Coastal Research Institute, Systems Analysis and Modelling

More than half of the world's population lives in coastal areas and this is an upward trend. Our coasts and coastal waters have always fulfilled numerous important functions. These areas are a source of food and natural resources – and also transport routes and energy sites. At the same time they provide space to relax and recuperate and a habitat for a wide variety of plants and animals. Awareness of their role as a climate regulator or carbon dioxide store has increased of late.

The term "coast" refers to the transitional zone between the land and the open sea. This includes drainage basins and estuaries, as well as tidal areas and coastal plains. From a geological point of view, coasts merely reflect a particular moment in time. Sea currents and tides, in particular, and the power of the waves, constantly gnaw at the coastline and change its course.

Endangered Environment

Today there is more and more pressure on these areas, which are vital to our daily lives and the economy. Two of the greatest problems are overfishing and the threat of harmful substances. The effects of global climate change have not yet been fully taken into account . There is a danger of an increase in North Sea winter storms. Moreover, storm surge water levels could also rise on the North Sea coast by the end of the century.

Sustainable management of the coast and marine environment is a decisive factor in safeguarding the natural environment and the livelihoods of those who live in it. The condition of the coast and sea can be reliably determined by means of coastal research. Harmful effects caused by humans, such as for example, oil pollution in conservation areas, can be avoided or the appropriate preventative measures taken.

Institute for Coastal Research

→ 180 employees
→ 3 Directors of Institute
→ Geesthacht Site

A piece of the seabed on board:
A coastal researcher is examining sediment samples on board the research vessel. These are evaluated against echolocation data.

Three questions to Prof. Dr. Hans von Storch

Director of Coastal Research Institute, Systems Analysis and Modelling

What is Coastal Research all about?

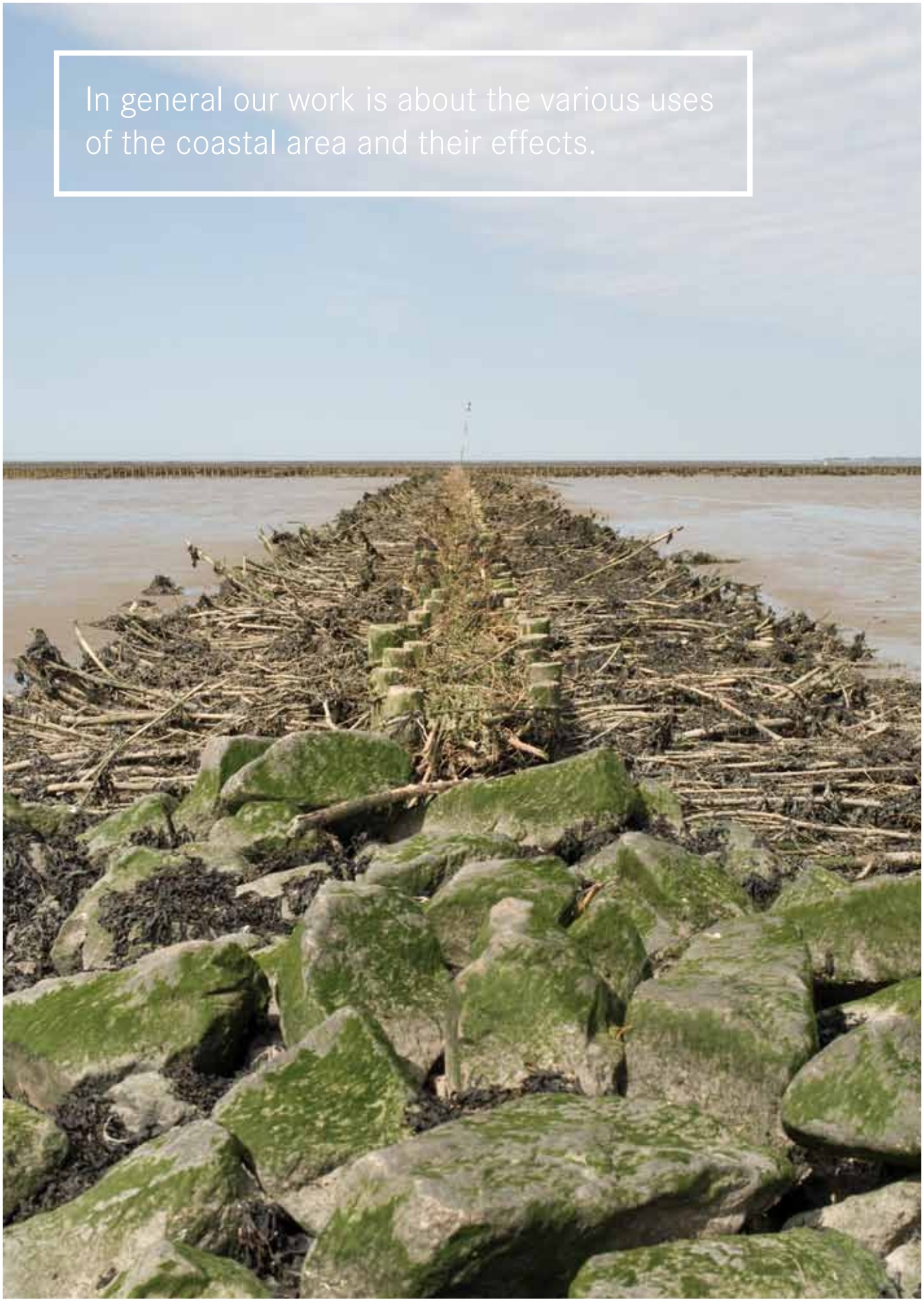
→ Our research spans both scientific and social aspects. In general it is about the various uses of coastal areas and the effects these uses have. We examine, for instance, the impact of oil pollution or offshore wind farms on tidal flats and the results of climate change in North Germany.

Which concrete tasks are the coastal researchers engaged in?

→ Many sections of the coastal habitat have not been adequately researched as yet. The various ecosystems interact in a multitude of ways, making their behaviour too complex and diverse. Our research questions include, for example: How will currents change in the long term? What causes the formation of algae blooms? What effect do rising temperatures have on the ecosystem?

What challenges do coastal researchers face?

→ The question is: How can processes occurring in the coastal zones be monitored reliably and economically? There are still not enough monitoring methods for the recording of chemical or ecological parameters, such as nutrients. Our scientists are spurred on by the desire to develop suitable instruments, methods and models in order to achieve this.



In general our work is about the various uses of the coastal area and their effects.

Radar on the Hörnum Lighthouse: sand transport, such as that on the west coast of Sylt, for example, can be determined from radar observations of currents and waves.

It is the aim of COSYNA (Coastal Observing System for Northern and Arctic Seas) to enable a reliable prognosis of the processes in the northern seas.

Focuses of Research

The coast in view

At present an extensive monitoring network, the System for Northern and Arctic Seas (COSYNA), is being set up in coastal areas of the North Sea and will later be extended to the Arctic Sea. In this project, data such as current speeds, temperature, wave height or chlorophyl content, is recorded from various sources by means of measuring buoys, fixed and movable sensors, automatic measuring units on vessels, satellite observations and radar systems and subsequently analysed in the data centre in Geesthacht.

The long term objective of COSYNA is to develop monitoring techniques which enable a reliable prognosis of the processes in the northern seas. This will be based on existing knowledge in the field of modelling, which has in part been developed and put into practice by coastal researchers in Geesthacht.

An image of nature

How do harmful substances spread in the tidal flats? What occurs after a blooming of algae? Those who wish to look into the future will need reliable data. Coastal researchers of the Helmholtz-Zentrum in Geesthacht provide meteorological and oceanographic model data for the North Sea and Baltic Sea regions. The data, which can be freely accessed on the Internet portal “coastDat”, do not refer to direct measurements, but are results of simulations with numerical models. This unique database is based on reconstructions of regional wave heights, wind and storm surges. The simulations apply to the past 50 years approx. and diverse future scenarios.

Assess risks – protect the environment

With the aid of coastDat, researchers simulate extreme water levels and storm surge scenarios or investigate the risks of oil pollution. Using a combination of current and wind data, calculations can be made to predict which coastal strips in the German Bight might be particularly affected by an oil spill and how probable this would be. These mathematical modelings of the complex coastal habitat are extremely comprehensive. Coastal researchers also use the facilities of the German Computing Centre for Climate and Earth System Research in Hamburg. Such calculations sometimes take days or even weeks.

The challenge of climate change – knowledge for North Germany

What climate changes will there be North Germany? Will storm surges be higher and which fruit trees can be planted there in future? The North German Climate Office in Geesthacht provides the answers to such questions. The staff give information on climate change in North Germany, offering advice to institutes, public authorities and businesses which have operational areas influenced by climate over the years. These include coastal preservation, tourism or agriculture. By forming a link between science and society, they ensure that climate research can be utilized by decision makers in North Germany.

The employees of the Institute for Coastal Research create the scientific basis for an accurate evaluation of the changes observed in coastal areas and the possible future effects. Their main objective is to contribute towards sustainable use of the coast. Scientists from diverse specialist disciplines work in close cooperation at the institute.

Current Research

The long life of toxic pollutants

Using air and water sample analysis and computer-aided transport models, the scientists examine how harmful pollutants spread, both regionally and globally, and determine the sources from which they originate. This work centres on organic pollutants such as those used in the impregnation of textiles, for example, or in flame retardants in the automobile industry. Some of these compounds are extremely long-lived and large concentrations accumulate in the food chain. As yet little research has been carried out with regard to their poisonous effects and how they find their way into the environment.

Chemistry on track

Those who wish to know how coastal areas are developing must also take a look at the sea bed. The sediments, i. e. the sand on the bed, play a great role in purification processes. Although the sea bed is an extremely important part of the ecosystem of shallow seas such as the North Sea and Baltic Sea, there have as yet been surprisingly few inclusions of sedementary processes in scientific models. This is an area in which coastal researchers in Geesthacht are providing important impulses to international shelf sea and coastal research.

Internationally linked

The project office “Land-Ocean Interactions in the Coastal Zone”, in short LOICZ, with its headquarters at the Institute of Coastal Research in Geesthacht, is part of an international network. It coordinates research projects worldwide, forming an interface between national, regional and international coastal research. Through the LOICZ, the Helmholtz-Zentrum Geesthacht focuses on the development, networking and promotion of global coastal research. The LOICZ is concerned with interdisciplinary issues regarding changes, and future scenarios for coastal areas throughout the world. Their endeavours centre on global change and the interaction between man and the environment.

Researching climate change in the Baltic region

Scientists from 13 European countries have compiled a report on climate change for the Baltic Sea region and published the first comprehensive review of these changes in the book “Assessment of Climate Change for the Baltic Sea Basin”. The BALTEX office, located in Geesthacht, has played a leading role in the coordination of this book project. According to this publication, the air temperatures in the Baltic Sea area could increase by up to five degrees centigrade by the year 2100. The calculations indicate that the surface temperature of the water of the Baltic Sea could possibly increase by two to four degrees centigrade. Further regional climate reports have been drawn up, including one for the metropolitan region of Hamburg.

Perceived security

Wind parks, fishing and tourist industries: human actions have an impact on coastal systems. What is the opinion of coastal communities on these activities? To what extent do they feel threatened by climate change? Geesthacht coastal researchers are carrying out socio-economic studies to gain a better understanding of the relationship between man and nature in the coastal regions.

Investigation of currents and swell

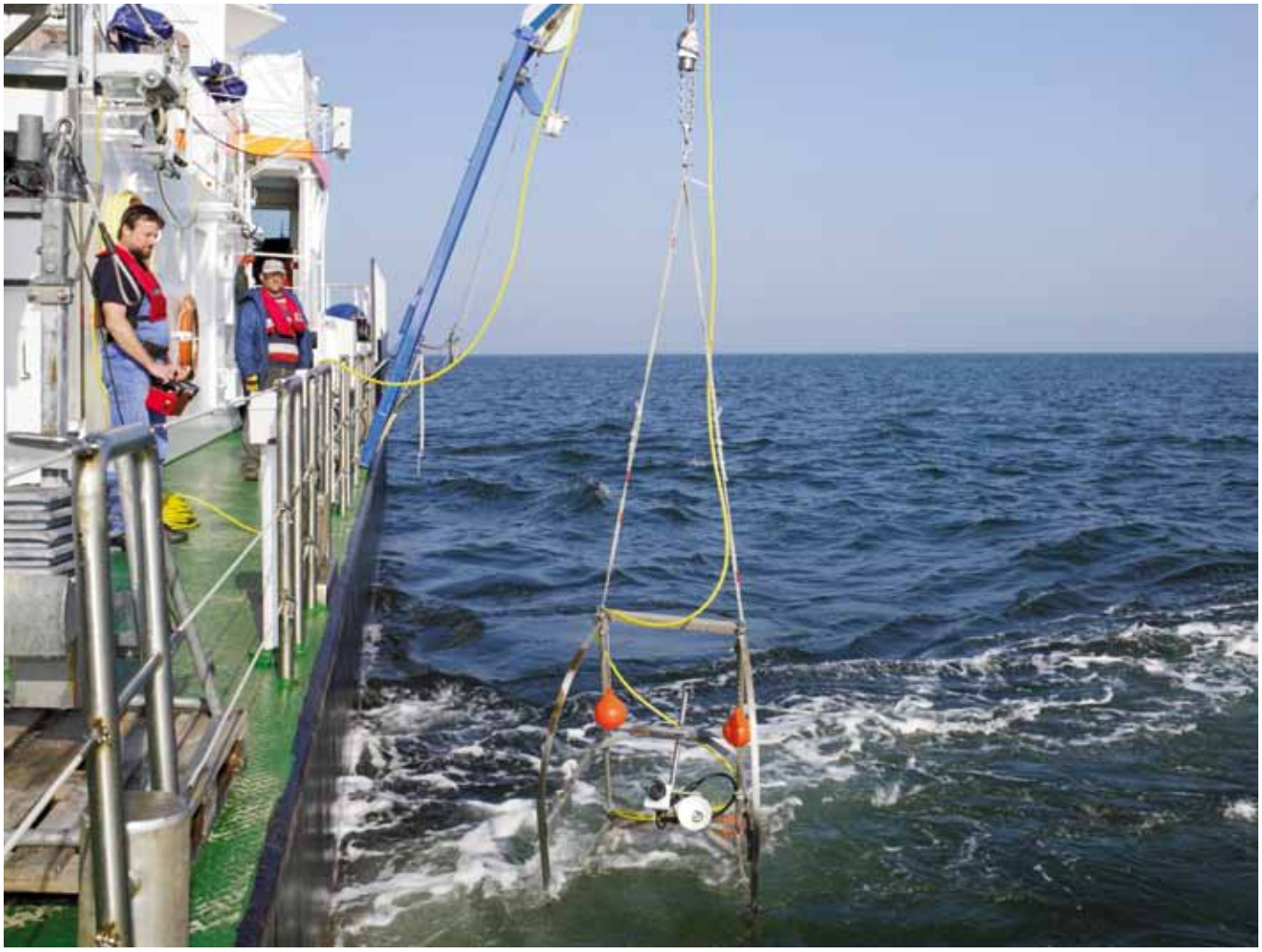
Extensive and continuous observations of swell, currents and winds can be made by means of the radar measuring methods which have been developed by coastal researchers. The determination of sand movements in coastal areas, such as on the west coast of Sylt, provides important information for coastal preservation.

Radar measurements are taken to provide more precise information about the behaviour of very high, steep waves, the so-called breakers. A radar device has been deployed on the ocean research platform FINO 3 in the North Sea for this purpose.

Left: The research ship “Ludwig Prandtl” near a measuring pole in the mud flats.

Right: Coastal researchers on board the “Ludwig Prandtl” are observing multibeam echo sounder measurements on the screen. These will subsequently be compared with real images of the sea bed.

Below: A video camera sled is being lowered into the water. It provides images of the topography of the sea bed.



CSC – Climate Service Center

How will insurances have to respond to the changes in risks? Will we still have ski slopes in the German Alps in the future? What changes will have to be made in the fields of road construction and water engineering? What can we – and what must we do?

More and more knowledge is available on climate change – consequently there is a growing demand for verifiable information. The Climate Service Center (CSC) was established in 2009 at the Helmholtz-Zentrum Geesthacht in order to facilitate the provision of research findings on climate change to the world of politics, science and business. The centre is part of the hightech strategy of the Ministry of Education and Research and receives its financial support. The CSC is under the directorship of the climatologist Prof. Guy Brasseur and has its headquarters in Hamburg.

CSC coordinates expertise on climate change

The CSC closes the gap between climate systems research and the users of climate information. It is an interface which links the decentralized knowledge of the various people involved in climate research with the requirements of the user. This involves an interpretation of results which has a sound scientific basis and includes advice on how to deal with scientific statements against the backdrop of the uncertainties associated with them. The CSC is a new platform which unites existing research institutions, climate consultancy services and the business world in a comprehensive network.

Using knowledge in a customer-oriented way

The advice on climate change is aimed, for example, at agriculture, the building industry, the financial sector, the power industry and the tourist industry. The CSC also provides advice for public administration authorities and politicians e.g. in the course of urban and spatial planning. A further focus is on users such as the media, the general public and applied science. The CSC is guided by the current requirements of its target groups and swiftly addresses questions arising from practice-oriented situations which require answers from the world of research.

The Helmholtz-Zentrum Geesthacht

Our centre is one of the most important scientific establishments in the North operating outside of the universities. Multifaceted research and development in the fields of Materials Research and Coastal Research have been concentrated here for over 50 years. //

Prof. Dr. Wolfgang Kaysser, Scientific Director

Scientific partners

Our scientists are engaged in research on the future of the coastal areas and the climate of the region. Material researchers utilise modern materials such as magnesium or titanium aluminide to make advances in lightweight construction for transport technology, and special plastics to further the development of fuel cells for hydrogen technology.

The scientists at the Teltow location near Berlin are developing biomaterials for the medical world of the future.

Science meets the World of Business

Research for practical applications – the Helmholtz-Zentrum Geesthacht offers a wide range of possibilities for cooperation with business enterprises. These include contract research and licensing for companies, publicly funded projects, scientific consulting and the provision of laboratory services. A separate department, “Technology Transfer”, advises and supports researchers who wish to set up their own companies.

Successful establishment of companies

Approximately 18 companies have so far been established by Helmholtz scientists from Geesthacht. Many of these young companies are located in the Geesthacht Innovation and Technology Centre (GITZ).

The close proximity to the research centre has proved to be a great competitive advantage for these spin-off companies, as close contact to their previous research colleagues and their scientific activities is retained.

Partners to the scientists

Scientists experiment – for these experiments they need laboratories, special apparatus and instruments. Laboratories, test stations and workshop facilities are available for their use on the research premises. The equipment needed for their work can prove more difficult. Frequently this cannot be merely ordered from a catalogue. In this case the Technical Centre comes to the aid of the researchers. The specialists in the Technical Centre develop the equipment required, or programme the software to be used.

From a high resolution tomography camera to a fine particle measuring probe or an underwater measuring buoy; qualified technicians work together with the scientists to develop solutions to even the most challenging tasks. The employees of the Technical Centre regard themselves as service providers and are the partners of science.

Left: Young scientists are given sound advice from the Department of Technology Transfer.

Right: More than 50 young people are offered future-oriented vocational training at the Helmholtz-Zentrum Geesthacht.

Below: Consultation, Planning and Production – the employees of the Technical Centre act as partners to the scientists.

Above: The very youngest begin experimenting at the nursery facilities of Helmholtz-Zentrum Geesthacht.

Below: In the student laboratory “Quantensprung” (Quantum Leap) school classes experiment with the professionals for a day.

The Helmholtz-Zentrum Geesthacht was awarded the certificate “audit berufundfamilie” (Work and Family Audit) for its committment to family-oriented policies.

Change of track welcomed

The vocational training offered by us is held in high regard by school leavers. The Helmholtz-Zentrum Geesthacht provides more than 50 vocational training positions. Training in non-academic areas is characterized by innovative concepts. The training project “Spurwechsel” (Change of Track) has, therefore, become well established in the Technology Centre. What is so special about this project? The apprentices, from office clerk to mechanic, organise themselves independently and in an interdisciplinary manner. This means that the complete process is entirely in the hands of the young people, from the acceptance of an order, through the planning and cost accounting stages, to the finished product.

Research like professionals

The student laboratory “Quantensprung” (Quantum Leap) has a reputation beyond the borders of Schleswig-Holstein. School pupils spend a whole day here, carrying out experiments on fuel cells or in the water analysis laboratory. Around 150 teachers and their pupils make use of this cost free provision each year. More than 30,000 pupils have so far spent an experience-packed day on the premises of the research centre.

“Einsteinchen” (Little Einstein) in the “Haus der kleinen Forscher” (House of the Little Researchers)

We run the nursery facility “Einsteinchen” in cooperation with the town of Geesthacht and the pme-Familienservice. This provision was especially set up for young scientists who often have a heavy workload and irregular working hours. The nursery facility “Einsteinchen” is part of the Helmholtz initiative “Haus der kleinen Forscher” (House of the Little Researchers). One of the objectives of this initiative is to make science and technology a living experience for children in pre-school facilities and thus promote education in early childhood.

Family-friendly research

Flexible or core working hours, a company-run care facility for children and the possibility to telecommute are some of the extensive range of family-oriented human resources policies of the research centre. As a result of this committment to the family, the research centre was awarded the nationally recognised certificate “audit berufundfamilie” (Work and Family Audit).

The Helmholtz Association

As a strong community we have the desire to convince young people that science is a fantastic profession which will enable them to not only put their ideas into practice, but will also offer an opportunity to achieve something which will later benefit society. //

Prof. Dr. Jürgen Mlynek, President of the Helmholtz Association

Alliance of Top Researchers

The Helmholtz-Zentrum Geesthacht is one of 17 centers within the Helmholtz Association. Scientific-technical and medical-biological research centres have joined forces to form this Research Association.

The research of the Helmholtz scientists in Geesthacht and Teltow is organised within the strategic programmes of the Association. The main focuses of the programme are divided into four research areas:

→ **Health**
Biomaterials with amazing properties are being developed at the "Centre for Biomaterial Research" in Teltow near Berlin. These biomaterials serve as a basis for diverse applications in the relatively new field of regenerative medicine.

→ **Key Technologies**
New materials and welding techniques are creating lighter cars and aircraft and thus helping to save energy. A unique wealth of expertise in the field of magnesium technology is concentrated in the Magnesium Innovations Center (MagIC). Scientists are also searching for solutions for emission-free power stations with the aid of specially developed membranes.

→ **Earth and Environment**
Coastal researchers are investigating the influence of global climate change at the regional level; in particular for North Germany and the Baltic Sea area. They use modern methods to monitor coastal areas and are continuing to improve these observation techniques. On board the "Ludwig Prandtl" our researchers assess the quality of the waters and examine the structure of the sea bed.

→ **Structure of Matter**
By means of synchrotron radiation and neutron flux, scientists are able to investigate materials and biological systems in a non-destructive manner and generate high quality three-dimensional images.

The 17 centres of the Helmholtz Association:

Alfred-Wegener-Institut für Polar- und Meeresforschung
(Alfred Wegener Institute for Polar and Marine Research)

Deutsches Elektronen-Synchrotron DESY

Deutsches Krebsforschungszentrum
(German Cancer Research Centre)

Deutsches Zentrum für Luft- und Raumfahrt
(German Aerospace Centre)

Deutsches Zentrum für Neurodegenerative Erkrankungen e. V.
(German Centre for Neurodegenerative Diseases)

Forschungszentrum Jülich

GSI Helmholtzzentrum für Schwerionenforschung
(Helmholtz Centre for Heavy Ion Research)

Helmholtz-Zentrum Berlin für Materialien und Energie

Helmholtz-Zentrum Dresden-Rossendorf

Helmholtz-Zentrum für Infektionsforschung
(Helmholtz Centre for Infection Research)

Helmholtz-Zentrum für Umweltforschung – UFZ
(Helmholtz Centre for Environmental Research)

Helmholtz-Zentrum Geesthacht, Zentrum für Material- und Küstenforschung GmbH
(Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research)

Helmholtz-Zentrum München
(German Research Centre for Environmental Health)

Helmholtz-Zentrum Potsdam Deutsches GeoForschungsZentrum – GFZ
(German Research Centre for Geosciences)

Karlsruher Institut für Technologie – KIT
(Karlsruhe Institute of Technology)

Max-Delbrück-Centrum für Molekulare Medizin (MDC) Berlin-Buch
(Max-Delbrück Centre for Molecular Medicine)

Max-Planck-Institut für Plasmaphysik
(Max-Planck Institute for Plasma Physics)

The Helmholtz Association makes an important contribution towards solving the largest and most urgent problems of society, science and commerce by means of its outstanding achievements in six research fields: Energy, Earth and Environment, Health, Key Technologies, Structure of Matter, Transport and Space. The Helmholtz Association is the largest scientifice organisation in Germany, with 25,700 employees in 17 Research centres and an annual budget of 2.3 billion euro.

The great natural scientist Hermann von Helmholtz (1821–1894) was one of the last true universal scholars. Helmholtz was a representative of the type of scientific research which forged bridges between the fields of medicine, physics and chemistry. His brilliant research work linked theory, experiment and practical application. Helmholtz founded the "Physikalisch-Technische Reichsanstalt" and served as its first president. The Reichsanstalt was the first scientific research centre worldwide which existed outside of the universities and is therfore considered to be the forerunner of the Helmholtz Association.

His field of research ranged from medicine, via physics and mathematics, to psychology, music and philosophy. One of his most lasting research achievements is his formulation of the law "On the conservation of energy". His research on hydrodynamics and the theory of electrodynamics pointed the way forward for later generations of scientists. Eye specialists and their patients owe a debt of gratitude to Helmholtz for the ophthalmoscope which enabled him to make the retina visible for the first time.

Helmholtz is also regarded as the founder of modern meteorology due to his mathematical studies on natural phenomenon such as hurricanes, thunderstorms, air and water waves and glaciers.

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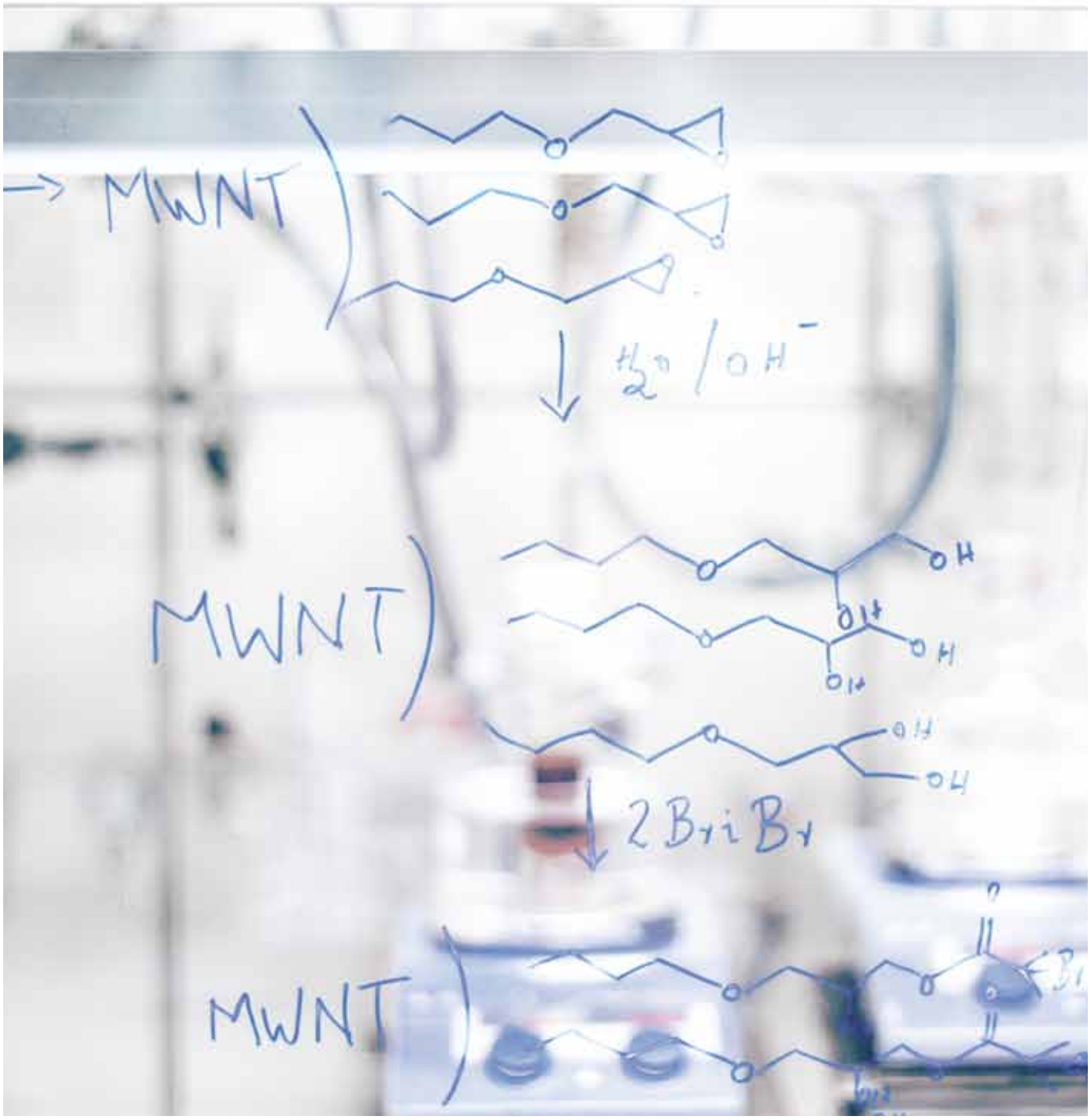
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