TELL'US

SCIENCE IN NORWAY

JUNE 2000

NEWS FROM THE RESEARCH COUNCIL OF NORWAY

Protecting nature through technology

The focus of this issue is man's interaction with nature and technology. The image of gushing springs and roaring waterfalls symbolises the challenges we face in respect of energy, the environment and prudent resource management.

A 4D in-the-body experience
Page 14

Seabed divulges new secrets
Page 20

Garbage bursting with energy
Page 30

Scallop kills bacteria in human beings and fish
Page 40

The Research Council of Norway

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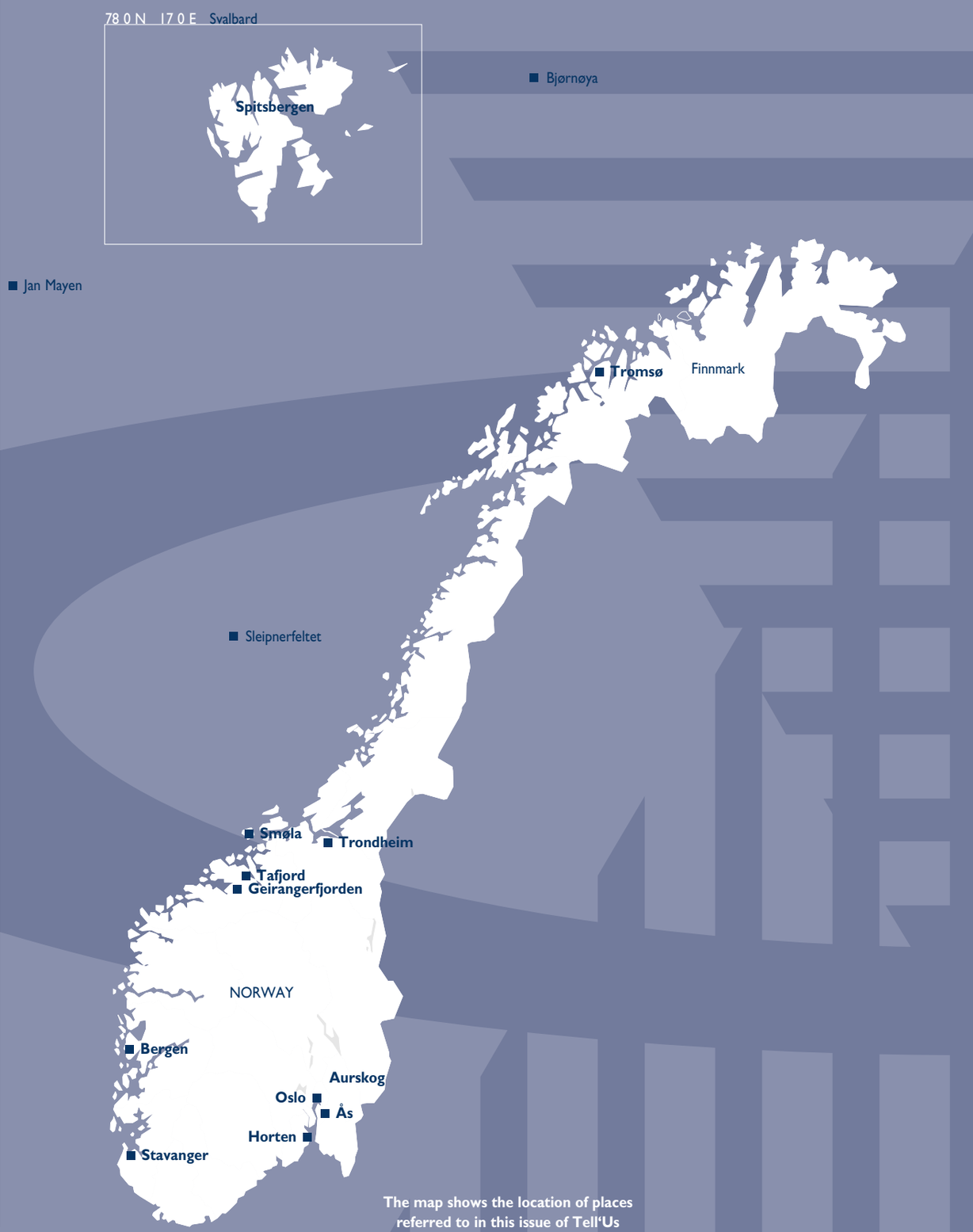
CONTENTS

Picture on cover:
Telefocus/Phil Lauro
Small pictures from top to bottom:
GE Vingmed Ultrasound
Eystein Jansen
Samfoto
Frank Gregersen, Fiskeriforskning

The Research Council of Norway



The map shows the location of places referred to in this issue of Tell'Us

EDITORIALS

Apropos

Norway's main target area, marine research, was the focus of a special issue of Tell'Us in 1998. This issue contains brief reviews of projects from a number of other fields of particular importance to Norway, including energy, the environment and polar research. In addition, it takes a more in-depth look at several ways in which technology is helping people lead better lives. For example, modern ultrasound technology is making it possible to see the inside of a human heart in real time, or to perform a virtual brain operation; computer technology is appreciably broadening the range of career and leisure opportunities available to the handicapped; and telemedicine is wiping out the distance between patients and the world's foremost specialists.

The overall topic addressed in this issue is how research-based innovations can contribute to solving the problems facing humankind. We have to have energy. We want to protect the environment. We want to be healthy and lead comfortable lives. We are biological creatures and, as such, we are dependent on the nature that surrounds us, even as we increasingly surround ourselves with technology.

Yet people are also spiritual beings, despite their affinity for technology and the natural sciences. Accordingly, you are invited to join us on a journey 1000 years back in time, as we take a new look at some rune stones and the messages our forefathers left behind.

Once praised as a panacea for humankind, science and technology are now being blamed for many of our problems. Yet it is only through research and the acquisition of knowledge that humankind has a hope of remedying its problems. After all, it is almost inevitably the possibility that they might make progress, through either applications or recognition, that drives researchers to pursue their ideas. There are also countless examples of how research has had unintended consequences or led to unexpected discoveries.

This touches on the very essence of what fascinates scientists – the chance that they may manage to overcome a new barrier, that is, the idea of setting out on an odyssey into the unknown. By the same token, we hope this issue of Tell'Us will transport you, our readers, on an pioneering journey into new terrain.
Enjoy!

Mona Gravningen Rygh
Editor

Energy, the environment and technology

The theme of the world's fair EXPO 2000 in Hannover, Germany, is "Humankind – Nature – Technology". The Norwegian Pavilion focuses special emphasis on energy and the environment, two fields of great importance that have long traditions in Norway.

The Research Council of Norway has devoted this special issue of Tell'Us to presenting some of the most outstanding contemporary Norwegian research projects that fall within the relatively broad parameters of the overall theme of the world's fair. The editorial board has slanted its selection of articles to accord with Norway's approach to the Hannover theme.

The Norwegian pavilion at EXPO 2000 has three separate areas for communicating with visitors:

The falls – a replica of the raging Steindal Falls, symbolising a powerful, clean, natural and renewable source of energy. The waterfall is 15 metres high, and features a water flow of 450 litres per second, adding up to 38 million litres per day. This is an invaluable source of renewable energy, reminiscent of Norway's abundant hydropower resources that provide power for industry as well as panoramic beauty for tourists.

The second area features an artistic installation created by the internationally renowned Norwegian artist Marianne Heske. Besides being a large work of art, the room itself is a product of high-tech Norwegian innovation. The walls, measuring 15 metres across and 15 metres high, are covered by abstract natural patterns. The images have been burned into more than 600 specially-treated aluminium sheets which were produced by hydropower. The overall effect imparts a very special feeling about man's role in the scheme of things.

Heske's point of departure for this digital image processing is a digitised picture from a small power-producing mountain village on the west coast of Norway, Tafjord, magnified more than two million times. The installation aspires to communicate the wish that humankind hold technology in high esteem.

The third area, the in-depth room, is intended to give visitors the opportunity to learn a little more about some of the research and development being conducted in Norway. All major industrial enterprises agree that research is crucial to product development. Accordingly, it seems natural for Norway to present examples from some of its leading research facilities, both those operated by private enterprises and those within scientific institutions.

The Research Council would like to project an image of Norway as a country which assigns high priority to research, and which has made considerable progress in key fields of research. The presentations are all under the same roof, which, by the way, is held in place by huge Norwegian glulam (glue laminated timber) girders, developed as a result of advanced research that opens whole new horizons for numerous types of constructions.

If you are lucky enough to visit EXPO – let these myriad impressions flow over you! If you are reading Tell'Us without having experienced the wonders of EXPO, you can look forward to learning more about a wide range of incredibly exciting research projects. In fact, the magazine contains more comprehensive and in-depth information than what we can possibly present at the Norwegian pavilion!

Paal Alme
Executive Director
The Research Council of Norway
Norway EXPO 2000 Board Member

DNA coding of oil

DNA codes can be programmed to carry alpha-numeric information using a PC. Artificial genetic material with the designed DNA code produced in a DNA synthesis machine can subsequently be used to imbue living or dead organic substances with an ID. This process does not use genes in the ordinary sense of the term, but rather molecules coded to contain numerous items of information.

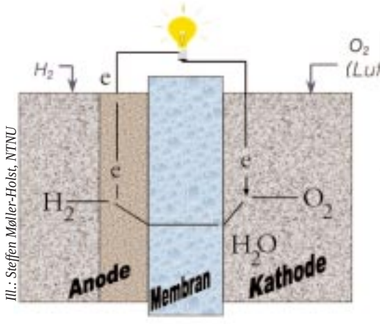
It was Professor Peter Aleström at the Norwegian School of Veterinary Science who conceived the idea for this novel application of gene technology. The idea has resulted in a new Norwegian company, ChemTAG AS, being established to offer the international market DNA-tagged bunker oil within the next few years. DNA tagging will make it easy to trace the culprits responsible for oil spills at sea, a major environmental problem the world over.

If the huge oil cargoes carried by supertankers were DNA-labelled, the oil itself would contain information about the vessel's owner, name, original point of loading the oil, when the oil was produced and by whom. In principle, any information can be included in a DNA code. ChemTAG is now collaborating with Det Norske Veritas (DNV) on a research project designed to find a foolproof system for DNA tagging all types of bunker oil. The company's CEO, Kjell J. Johnsen, expects that a similar tagging system for cargoes of ordinary oil will be ready for launch soon after the system for bunker oil is in place.

To foster the establishment of businesses based on the commercialisation of research results, the Norwegian Industrial and Regional Development Fund, the Research Council of Norway, universities, colleges and the country's research parks have joined forces to initiate a programme called FORNY, designed to promote research-based innovation. The research parks will be in charge of finding partners and funding, and then administrate projects as they are launched. One of the most successful projects to come to fruition under the FORNY programme, ChemTAG is affiliated with the Research Park in Ås.

Mona Gravningen Rygh

OIL SPILLS: DNA-labelling oil should make it easy to track down polluters. From Ytre Sula, Norway. (Photo: Samfoto)



Ill.: Steffen Møller-Holst, NTNU

Fuelling a silent revolution

A fuel cell is an electrochemical energy device which produces electricity, water and heat on the basis of fuel (hydrogen) and oxygen in the air.

Norway has proud traditions as a seafaring nation. However, it takes energy to propel even the most environment-friendly ships, and the use of fossil fuels leads to CO_2 and NO_x emissions. Now Norwegian researchers believe they may have a solution in sight. The Norwegian University of Science and Technology (NTNU), the Institute for Energy Technology and Norsk Hydro will be joining forces to determine the feasibility of using hydrogen fuel cells to power the Norwegian transport sector. The researchers plan to build a hydrogen-powered ferry by 2003–04.

The project is receiving support from the Research Council of Norway's programme for Efficient and Renewable Technologies (NYTEK).

Considering that its discovery dates back to 1839, the fuel cell is hardly a new invention. Yet research on fuel cells did not really 'take off' until in the 1960s when NASA demonstrated their potential as an energy supplier on a journey into outer space (where the astronauts drank the waste product produced by the fuel cell – water!).

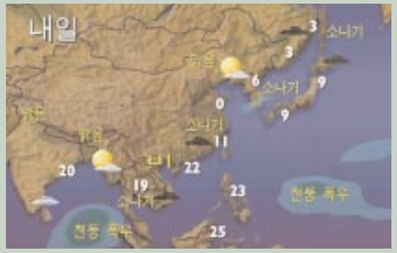
"There is a great deal going on in this field today", comments Steffen Møller Holst, a researcher at NTNU. "Several automotive manufacturers are talking about putting hydrogen-fuelled cars into mass production already from 2003 or 2004. A significant portion of Norway's CO_2 and NO_x emissions comes from sea transport. As both an energy nation and a seafaring nation, we are in an excellent position to take advantage of opportunities that arise in this area."

A fuel cell is a voltaic couple, that is, it generates electricity from chemical reactions. A fuel cell stack (a series consisting of many individual cells) might best be compared with a battery that never runs out of energy. When hydrogen fuel is added, the fuel cell's environmental advantages become obvious: A high utilisation factor, exhaust that consists of steam, and a process that is virtually silent.

There are a number of different types of fuel cells available today, and each one will no doubt eventually find its market niche. "The transport sector will use PEM (polymer electrolyte membrane) cells. They have a simple design, high energy density, high efficiency and low operating temperature which ensures quick starting", explains Møller Holst, who has great confidence in the future of the fuel cell.

Mette Irene Dahl

Clear skies ahead for a billion viewers



GLOBAL WEATHER. Metaphor Systems has supplied weather forecasting technology to nearly 70 TV stations in every part of the globe. The weather forecasts seen by roughly 1 billion viewers reach their TV screens through the marvels of Norwegian-produced software. (Illustration: Metaphor Systems)

Entrepreneur Karl Eggestad delivered his first weather forecasting system to Norway's national commercial broadcasting station TV2 in 1993. In 1994, Denmark's TV2 bought the system and in 1996, Eggestad signed a contract with the US-based broadcaster CNN. As of February 2000, Metaphor Systems has supplied weather forecasting technology to nearly 70 TV stations in every corner of the globe, reaching more than 1 billion TV viewers.

"When CNN asked me to come to Atlanta and install our production and presentation system, I realised we had a success on our hands", smiles Eggestad in retrospect.

In 1993, TV stations all over the world had employees entering high pressure ridges and cold fronts into drawing programs, often on the basis of hand-sketched instructions made by the stations' meteorologists. Naturally, their interest was piqued when they saw Eggestad's invention: A production and presentation system that went straight to the heart of meteorologists' complex calculations, converting their results into animated TV images automatically.

When Danish TV2 bought the system in 1994, Eggestad decided it was high time to cash in on his idea. He therefore contacted the Research Council of Norway's Programme for the Commercialisation of Research-based Ideas (FORNY). They agreed to finance a market survey in the summer of 1995 to find out what sort of weather technology European TV stations were using and what their goals were in this area.

In December 1995, Eggestad founded Metaphor Systems in collaboration with SINTEF. The system is ten times larger now than it was then. Metaphor Systems: http://www.metaphor.no/

Svein Tønseth, SME Review

TH!NK of a car

The electric car TH!NK is the first fully fledged automobile Norway has ever exported to Europe. Type-approved pursuant to EU standards in 1998, the car is made of a solid-colour moulded thermoplastic polyethylene shell, supported by a steel undercarriage and a welded aluminium space frame.

The idea behind TH!NK is based on three principles: 1) environment-friendly production – including painting; 2) environment-friendly operation – electric. 3) environment-friendly disposal – simple to disassemble, easy to recycle.

Based on materials never before used in car production, TH!NK cars are made using innovative new assembly technology, a specially developed assembly line and a special factory layout.

TH!NK is manufactured in Norway by TH!NK Nordic AS, which is in the process of building up an international centre of knowledge and expertise about light, ultramodern cars. The idea is for Norway to be the centre for R&D and technological developments in the field of energy efficiency, drive systems, materials and building and process technology, while the car will be assembled in the field, i.e., in the individual markets. TH!NK Nordic is engaged in continuous R&D in respect of the various models of TH!NK, co-operating with other R&D groups in national and international arenas.

The initial idea for the TH!NK project was conceived in 1973, and a development company under the name Pivco AS was founded in 1990. The enterprise has received substantial state support through the Research Council of Norway and the State Industrial and Regional Development Fund. The project was awarded EUREKA (European network for market-oriented R&D) status in 1993. In 1999, the Ford Motor Company acquired 51 per cent of the enterprise and changed the name to TH!NK Nordic AS. At the beginning of this year Ford Motor Company acquired the rest of the shares. The cars are being produces at Aurskog, approximately 50 km East of Oslo.

The plant has the capacity to produce 5000 vehicles per year.

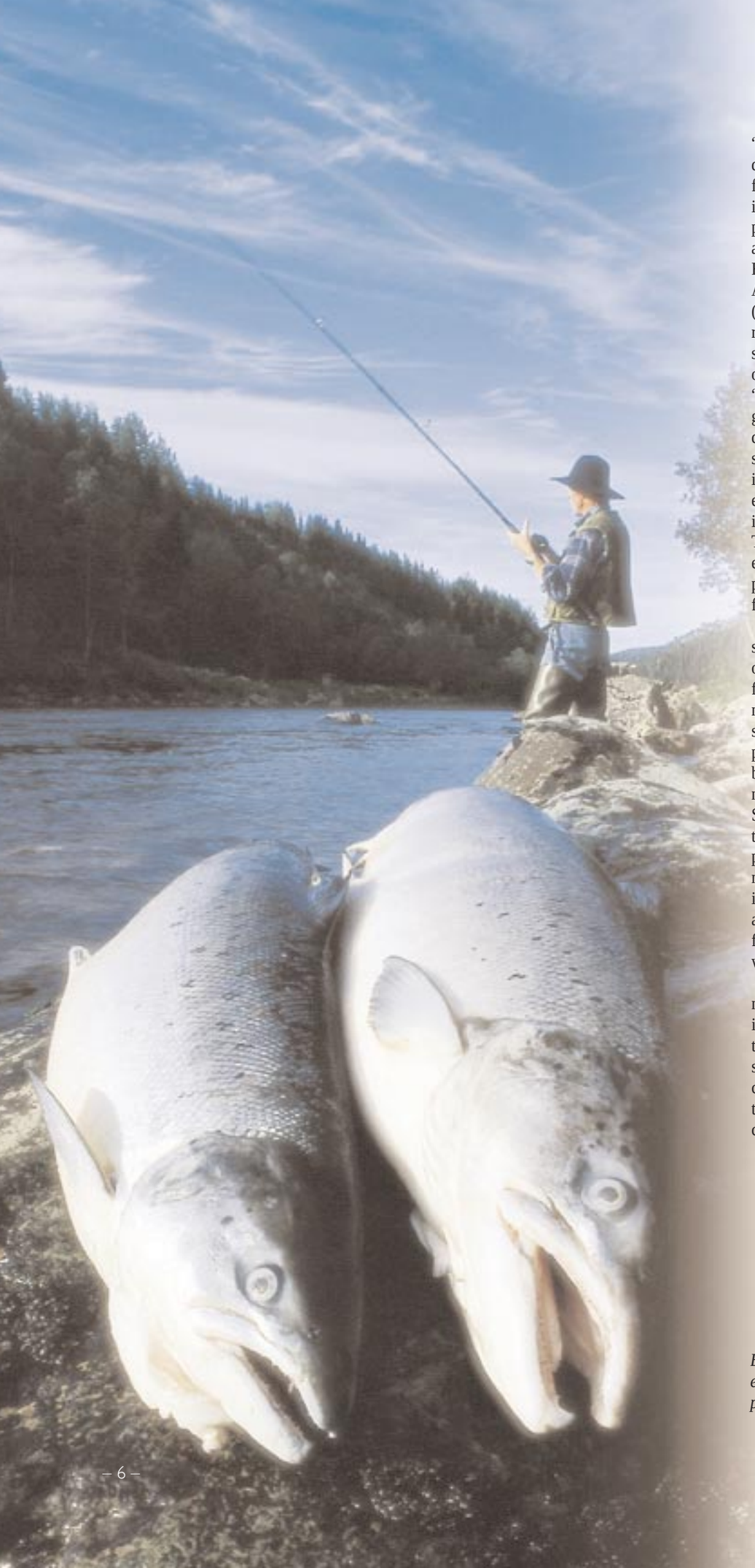
Norway has been the site of numerous measures designed to promote the use of electric cars, ranging from reducing automotive registration fees, annual licence fees and scrapping fee, to offering free passage on toll roads and free public parking.

Website: www.think.no

Mona Gravningen Rygh

FOR THE FUTURE: TH!NK cars offer environmentally friendly production, use and disposal. Picture from Oslo. (Photo: TH!NK Nordic AS)

Suffering salmon?



BIG SALMON: Do we face an ethical dilemma if fish feel pain?

(Photo: Samfoto)

"Do we face an ethical dilemma if fish can actually feel pain, and is their suffering, if it does exist, of independent moral importance?" asks Senior Lecturer Andreas Føllesdal of the Faculty of Arts at the University of Oslo (UiO). He is heading a research project entitled "Can salmon suffer?" which is part of the Research Council's "Salmon production" programme. The project will determine whether fish can suffer in the sense referred to in regulations concerning experiments on animals and in general ethical reflections. The project calls upon the expertise of theologians, philosophers, biologists and fish physiologists.

Fish farming is Norway's second most important source of export revenues. In the fisheries industry, reference is made to production-related suffering which involves pushing a species' biology beyond the limits of what is natural, in the strictest sense. Such pragmatic considerations put a fine but urgent point on the question of animal welfare and fishing industry management. Why are we less concerned about fish welfare than mammal welfare?

"Our perception of animals is anthropocentric, that is, it is based on man being the centre of the universe. We see animals either with the callousness of the hunter or the scientist, or with caring, compassion and empathy", contends dr.med.vet. Bergljot Børresen, author of "The Lonely Ape." According to her, we do this because people are equipped with a toggle switch in their brains that allows them to turn on and off their ability to get emotionally involved with other species. For example, a hunter views an animal exclusively as prey, 'turning off' his sense of compassion during the hunt. Then he carries his prey home, lights the fireplace and 'turns on' the emotional toggle switch to cuddle with his dog. Fish, on the other hand, do not exchange contact signals with people, nor do they signal pain, meaning they do not arouse any feelings of empathy in people. In plain English, their 'Bambi factor' is too low.

Yet the concept of 'pain' can be interpreted in different ways. According to Trond Brattelid from the School of Veterinary Science in Oslo, fish receive pain signals through pain receptors located in the tail, finns and around the mouth and eyes. The signals are transmitted through the neural system to the cortex of the brain, where they are processed and possibly interpreted as pain.

"Fish have a small cortex, and they are not equipped with a neocortex, which some would contend is a prerequisite for feeling pain. There is therefore considerable uncertainty about whether fish actually experience what we define as pain", Brattelid points out. "Yet fish have a telencephalon or endbrain, and it may play a part in fear, suffering and learning. In any event, it will be up to the salmon researchers or fish farmers to interpret piscine pain signals based on fish behaviour." Brattelid adds that attempts to escape, changes in pigmentation and similar behaviour may all be indicative of pain.

Anita K. L. Thorolvsen

The enemy without

"Groups of astronauts who spend long periods of time in outer space often develop a strong sense of loyalty to each other and tend to perceive those outside the space station as their enemies. This mechanism allows them to deflect their aggressions and avoid unpleasant disagreements", reports Senior Lecturer Gro Mjeldheim Sandal at the Department of Social Psychology at the University of Bergen. Sandal is part of an international space research programme aimed at identifying the psychological reactions of individuals who spend long periods of time in outer space.

"Good communication is essential in this type of group. Communication can be measured against the extent of misjudgements. Even though the astronauts channel their aggressions towards the outside to preserve their sense of solidarity, irritation and the lack of privacy are among the most significant stress factors. The most critical phases of a space odyssey appear to be at the midway point and towards the end. This may have something to do with the special perception of time which cosmonauts develop", states Sandal.

Many of the psychological finds from space research are probably applicable to the everyday lives of people in general.

"A large part of my research focuses on how to put together teams that work. Business and industry are crying out for this type of documented knowledge", says Sandal, whose main field of interest is personality and organisational psychology.

Hilde Bøyum, På Høyden

LOYALTY. Cosmonauts who spend long periods of time in space often develop a strong sense of solidarity with each other and tend to perceive those outside their group as 'the enemy'. (Photo: Image Bank)

Internet kick-off in Oslo

THE BIRTH OF THE INTERNET: In 1983, Oslo's Holmenkollen Park Hotel was the venue for the very first meeting convened to consider establishing a global computer network. (Photo: Pippip)

1983 was a watershed year for the Internet. It marked the very first meeting convened to discuss the idea of a global network, and the meeting was held in Oslo. The main players from Norway were Pål Spilling, then of the Norwegian Defence Research Establishment, now a professor at the University of Oslo, and Rolf Nordhagen, then EDP manager, also now at the University of Oslo. The two are considered the 'fathers' of the Internet in Norway.

Yet the real history of the Internet dates back to the University of California in 1969: Two computers were linked together for the first time to form the Internet's predecessor, the US national network called *Arpanet*. In 1973, Norway became the first country outside the USA to be linked to the *Arpanet.* Spilling was working at the Norwegian Defence Research Establishment in 1974 when he was invited to take part in *Arpanet*, a collaborative project that made Norway a pioneer in Internet development outside the USA.

As time passed, Norwegian universities began developing a system that eventually became the academic computer network *Uninet*. In the early 1980s, there were still just two countries outside the USA trying to implement a national computer network: Great Britain with *Janet* and Norway with *Uninet*. Somewhat later, the Nordic countries began collaborating, resulting in the *Nordunet*, and making the Nordic region a major power in European network cooperation.

Larry Landweber of the University of Wisconsin, the man in charge of the American *CSNet*, took the initiative for the historic meeting convened to consider establishing a global research network. A dozen representatives from various walks of life and different countries attended the meeting. At a hotel with a panoramic view of Oslo and the vast forests, fjords and mountains in and around the city, the participants managed to find common ground and a common pioneer spirit, despite the fact that there was some disagreement about technological solutions. The Oslo meeting was the first in a series of events that preceded the first official international conference of the Internet Society in 1991. Rumour has it that back in the summer of 1983, the founding fathers' discussion continued in Nordhagen's garden into the wee small hours of the morning, waiting for the darkness that never came in the Land of the Midnight Sun.

Mona Gravningen Rygh

Seabed segregation

Human beings are not the only ones fond of the taste of that much sought-after delicacy, the scallop. Edible crabs like them too. What is more, the edible crab, also known as the brown crab, prefers cultivated scallops to wild scallops of the same size and age. In a project under the auspices of the Research Council's programme "Farmed marine species", researchers at the Institute of Marine Research, Centre for Aquaculture, have now shown that 30 cm high steel plates erected like fences on the seabed are an effective means of keeping edible crabs on the right side of the fence to prevent them from feasting on beds of vulnerable farmed scallops.

"We are testing the system in collaboration with some industrial players. With a few modifications to the methods and equipment, this looks as though it may be a cost-effective way of protecting farmed scallops destined for human dinner tables", comments Øivind Strand, a researcher at the Institute of Marine Research.

"Scallops are delicious, I love them! As do most people. I have yet to meet anyone who doesn't like scallops that have been prepared correctly", adds Strand. Since 1996, he has been working on how to cultivate scallops on the seabed. More research will be necessary to develop scallop farming methods that are sufficiently commercial to take advantage of the huge export market demand that exists. More than 50 000 metric tonnes of scallops are sold each year in France alone.

Anita K. L. Thorolvsen

Photo: Geir Askvik Haugum

Ominous Arctic Omens

THE ARCTIC ICE IS MELTING: If the multi-year Arctic ice continues to melt at the same rate it has done for the past 20 years, the seas surrounding the North pole could be completely ice-free during summertime in 50 to 100 years' time. (Photo: Samfoto)

The latest results indicate that the Arctic ice cap is melting twice as fast as previously expected. Should this trend continue, the entire Arctic could be sans summer snow and ice just 50 to 100 years from now.

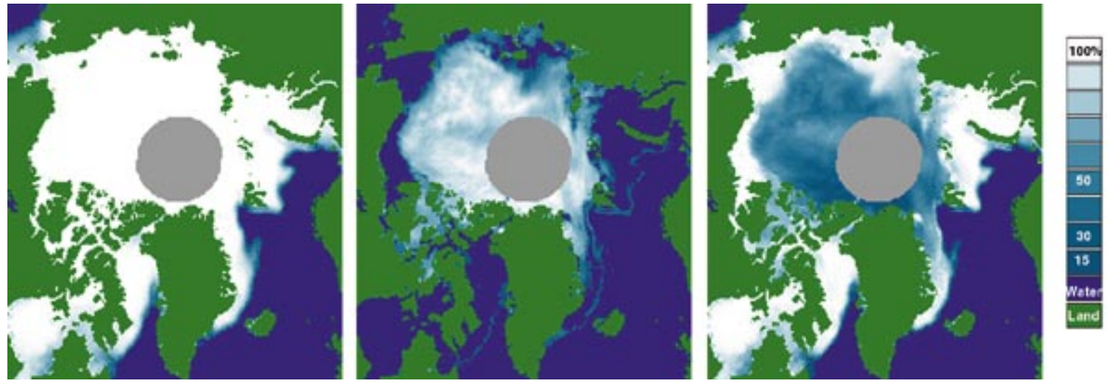
BY BJARNE RØSJØ

Arctic sea ice is a sensitive indicator of climatic change, and climate models predict that global warming due to the greenhouse effect will have a stronger impact on the areas around the North Pole than other places. Accordingly, it created quite a sensation when oceanographer Ola M. Johannessen and two of his colleagues recently used satellite observations to determine that multi-year Arctic ice has been reduced by a whopping 14 per cent over the past two decades.

Earlier research results, including results produced by Johannesen's own group, indicated that the total ice cover had been reduced by about 6 per cent during the same period. The new results indicate that the Arctic ice is melting twice as fast as previously believed. No wonder Johannessen has been contacted by so many people from all over the world since the results were published recently in *Science*, the prestigious US research journal.

NO ICE IN 50 TO 100 YEARS

"In 1995, we published an article in *Nature*, confirming that the total Arctic ice cap had been reduced by 3 per cent per decade from 1978 to 1995. This time round, we've had a look at multi-year ice, which is thicker than first ice, so it creates more volume and mass. We were surprised to ascertain that the area covered by multi-year ice had diminished by 14 per cent, the equivalent of, 7 per cent per decade. These results are highly significant since they indicate that the entire relationship between first ice and multi-year ice is in the process of ▸



FIRST ICE AND MULTI-YEAR ICE: The total amount of ice in the seas surrounding the North pole (left on map) consists in reality of multi-year ice (right) and first ice. The area covered by multi-year ice has diminished by 14 per cent since this survey was first conducted in 1978.
(Illustration: NRSC)

changing. It is not yet possible to tell whether this is being caused by global warming since satellite measurements are only available for the past 20 years. On the other hand, it is a strong indication", states Johannessen.

"Does this mean the Arctic ice may disappear completely?"

"We don't know yet, but the trend is ominous. If the cover of multi-year ice continues to diminish at this rate, there will be no summer ice left in the Arctic 50 to 100 years from now", is the response. "But that also depends on whether this is a natural long periodic fluctuation caused by 'the Arctic Oscillation', which is primarily an atmospheric phenomenon."

ABSORBING MORE CO_2

"What would happen if the sea ice were to disappear?"

"The ocean's capacity to absorb CO_2 from the atmosphere increases as temperatures drop. Today, the oceans of the world contain about 50 times more CO_2 than the atmosphere. At the same time, six or seven gigatonnes of Carbon, or 22 to 26 gigatonnes of CO_2, are being released into the atmosphere every year as a result of human activities, and one-third of that amount is absorbed by the ocean after a certain number of years. If the Arctic areas with cold, open waters were to expand, even more CO_2 would be absorbed. In the long run, this might help reduce global warming, which would be a positive effect of the melting of sea ice. But we are still not sure how much CO_2 would be absorbed", continues Johannessen.

Preliminary rough estimates indicate that ice-free Arctic seas could potentially absorb between 0.3 and 0.6 gigatonnes per year, an increase of 15 to 30 per cent compared with today's absorption level. To put this into perspective, this amount accounts for 5 to 10 per cent of the today's anthropogenic emissions of greenhouse gases, which is about the same amount as the Kyoto Protocol is attempting to reduce.

A CLIMATIC HARBINGER

In the December 1999 issue of *Science*, the journalist Richard Kerr explains that climatologists use the Arctic ice to harbinger danger, the same way miners used to use canaries to detect hazardous gases in times past.

An ice melt "would convert the Arctic Ocean from a brilliantly white reflector sending 80 % of solar energy back into space, into a heat collector absorbing 80 % of incident sunlight, with effects on ocean and atmospheric circulation extending into mid-latitudes", said the polar researcher John Walsh of the University of Illinois to Kerr.

This new information has been gleaned from studies of data transmitted by US satellites that have measured passive radiation levels from the ice in the microwave range.

"We have had access to a 20-year series of measurements which began with the Nimbus 7 satellite in 1978. These very high-quality data are based on the principle that first ice and multi-year ice, that is, ice which has survived the first summer, have different radiation levels. This is because Arctic ice is formed from seawater with a salinity of 35 parts per thousand. During the first winter, the salinity level of the ice is reduced to 3 or 4 parts per thousand, which has an effect on radiation levels", continues Johannessen.

"Multi-year ice is comprised of water which is virtually fresh, since it continues to desalinate. However, it is only possible to distinguish first year from multi-year ice if the snow cover is dry, meaning the distinction cannot be made in the summer when the snow is wet".

CORROBORATING EVIDENCE

Other observations indicate little change in the Antarctic ice, and that is also as expected on the basis of the climate models. Johannessen also refers to other research results that corroborate the conclusions drawn in the article published in *Science*.

"Russian researchers calculated ice thicknesses in the Arctic from 1972 to 1991 using equipment that measured how North Atlantic ocean swells are dampened when they propogate into the ice. We found a remarkable correlation between the satellite measurements and the Russian measurements, which indicated that the ice thickness was being reduced by an average of one-half centimetre per year. Unfortunately, the Russian research was discontinued in 1991 due to a lack of funding", sighs Johannessen.

After studying a series of sonar measurements taken by US nuclear submarines, American researchers recently concluded that the ice thickness has been reduced by 1.3 metres over the past 30 years. That comes out to an average of four cm per year.

"Granted, there is a huge gap between the Russian and American measurements, but whether the results are one-half cm or four cm, the depletion is disquieting. We need to take a closer look at the discrepancy between the measurements. Generally speaking, it is no mean feat to measure ice thicknesses over vast areas. More attention should be devoted to this in future."

At this point in the interview, it was time for a few words of comfort.

"I have no desire to be a prophet of doom, so I must add that this emerging trend may also have positive effects. A reduction in Arctic ice might make it easier to operate fish farms and to open shipping lanes through these areas. It is also very important to bear in mind that ocean water levels will not rise as Arctic ice melts", he points out.

A NORWEGIAN RESPONSIBILITY

Johannessen observes that, on the down side, melting would produce huge volumes of freshwater, which could have tremendous consequences. The ocean's thermohaline circulation (affected by temperature and salinity) is largely determined by deepwater formation in the polar areas, and that would be disrupted if large quantities of freshwater were introduced at the surface. Less deepwater formation would raise havoc with ocean circulation, and could even have a mitigating effect on the Gulf Stream, which carries warm water from the Gulf of Mexico to northern Europe.

"The Norwegian Sea, the Greenland Sea, the Barents Sea and the Arctic areas are the key to a large part of global ocean circulation! Remember, a given volume of water carried down into the Greenland Sea in connection with deepwater formation, emerges again in the Pacific about 800 years later", the oceanographer points out by way of conclusion.

AN ECO-MELTDOWN?
If the Arctic summer ice disappears, possibilities may open up to operate fish farms and open shipping lanes through these areas. However, the increased amount of fresh water may also disturb the climate along the Norwegian coast.
(Photo: Samfoto)

Research in the name of Nansen

Professor Ola M. Johannessen is an oceanographer and founding director of the Nansen Environmental and Remote Sensing Centre (NERSC) in Bergen. He also works at the Geophysical Institute at the University of Bergen. The research discussed in this article has been performed in collaboration with Elena V. Shalina of the Nansen International Environmental and Remote Sensing Centre (NIERSC) in St. Petersburg (Russia), and Martin W. Miles of the Nansen Centre in Bergen and the Institute of Geography at the University of Bergen. The Research Council of Norway, the Norwegian Space Centre and the International Association for the Promotion of Co-operation with Scientists from the New Independent States of the former Soviet Union (INTAS) have provided funding for this research.

NERSC scientists have been inspired by the life of Fridtjof Nansen (1861–1930), renowned Norwegian biologist, oceanographer, polar explorer, diplomat, humanist and 1922 Nobel Peace Prize laureate. The Fram expedition, conceived and led by Nansen to chart Arctic waters by freezing a ship into the pack ice and allowing it to drift for three years, was completed in 1896, laying the foundation for research in the Arctic Ocean.

NERSC and NIERSC: http://www.nrsc.no

Fjords – food factories of the future?

According to calculations performed by an interdisciplinary group of researchers associated with the University of Bergen (UiB), it may some day be possible to make the fjords along the west coast of Norway into veritable food factories. The researchers have used the university's supercomputer to verify that their theory is valid, and now it is about to be tested in practice.

BY BÅRD AMUNDSEN

Slicing incisively into the west coast of the country, Norway's fjords were formed by glacial action and some are more than 1000 metres deep. The idea of turning the fjords into food factories is based on these extreme depths and on the fact that the rivers at the heads of the fjords ensure a constant supply of fresh water.

Tremendous quantities of waste are produced in seas, oceans and fjords. The waste breaks down and acts as a sort of natural fertiliser to make oceans and fjords into seemingly inexhaustible reservoirs of nutrients. The problem is that most of these nutrients are never used. They simply fade away as they sink, disappearing to depths at which they are transformed into nothing more than putrefaction gases. Generally speaking, sunlight penetrates only about 50 metres (the euphotic zone), leaving the deeper strata of the oceanic province and the Norwegian fjords pitch-dark watery wastelands.

A very small part of the total area covered by oceans, mainly the areas along coastlines and in shallow fishing grounds, accounts for almost all the production of fish and other marine foods harvested by man.

SIMPLE AND CHEAP

It was Professor Arne Foldvik of the Geophysics Institute at the University of Bergen, who conceived the idea of capitalising on the vast amounts of nutrients that normally turn into ooze at the bottom of the deep fjords. He proposed enclosing the two last metres of the river at the head of a fjord in a pipe, then diverting the river water down towards the bed of the fjord. So doing would stimulate circulation in the seawater, stirring up the vast quantities of nutrients from the fjord floor and bringing them up into the euphotic zone.

The same currents would also help to bring new, nutrient-rich seawater into the fjord from the ocean outside it. The freshwater current would quite simply act as a catalyst for a process through which the influx of new nutrients would initially fertilise the phytoplankton in the fjords. The phytoplankton would then be eaten by the zooplankton, which would in turn be eaten by fish or shellfish, which would ultimately be eaten by humans.

Professor Jarle Berntsen of the Department of Applied Mathematics in Bergen undertook the task of translating Professor Foldvik's into a huge arithmetical problem. Berntsen was quick to realise that he needed large amounts of heavy-duty computer power to calculate and quantify the effects of currents, factoring in seawater, nutrient salts and other biological variables. Accordingly, he fed his problem into UiB's Cray Origin 2000 supercomputer, which is capable of performing more than 50 billion calculations per second. Notwithstanding its incredible capacity, the Cray used several days to work its way through the problem. Ultimately, however, the answer was clear: The Norwegian fjords should be able to convert enormous amounts of unexploited nutrients into a veritable marine feast.

THE FIRST TEST

Researchers in Bergen have been given a green light to test whether the whole concept is feasible in practice. The test will be run in the Samnanger Fjord, south-east of Bergen. The experiments should show whether, for example, the influx of new nutrients will support large numbers of sea trout. Or perhaps the production of shellfish in the longer fjords could be increased by 500 to 800 per cent?

Professor Berntsen underscores that the point is not to introduce artificial nutrients from an external source, as is the case with ordinary fish farming. Instead, the project is based on using existing nutrients for genuinely new food production. On paper, it looks as though this type of production has far more potential than salmon farming, even though salmon farming in Norway is second only to petroleum as an export product.

The supercomputer in Bergen tells us that the project is possible in theory. Soon we will know whether it will work in actual practice.

FJORD FOOD FACTORIES: The Geiranger Fjord and the other beautiful fjords along the west coast of Norway's are among the country's foremost tourist attractions. In future, they may also be making important contributions to the world food supply. (Photo: Samfoto)

Crunching problems by crunching numbers

Powerful computers, also referred to as supercomputers, currently play a key role in a number of fields of research. The supercomputers at the universities of Bergen, Trondheim and Oslo have brought Norwegian research many small, and a few giant, steps forward.

Over the past four years, the Research Council of Norway has channelled more than MNOK 100 through the Computational Science Programme to finance the three supercomputers and their operation. The investment has enabled a large number of Norwegian researchers to keep up with the work done by their colleagues abroad, and it has put a few researchers at the forefront of developments in their chosen subject areas. The outstanding research done on superconductors at the University of Trondheim is a sterling example of this.

1000 PROJECTS

Supercomputers have become as indispensable as lab equipment in fields such as chemistry, physics and geophysics. Mathematicians and pharmacists are also turning their attention to computational science, and subjects such as biology, economics and medicine are likely to account for important applications in future.

The Computational Science Programme has supported a total of 169 post-graduate students and 149 graduate students by giving them time on the three supercomputers. In one way or another, more than 1000 research projects have benefited from the computational resources provided.

STILL GOING STRONG

One rule of thumb in the computer world is that you will get twice as much data capacity for your money in 18 months. Accordingly, when an expensive supercomputer rolls through the gates of a university, it is essential to get it up and running as soon as possible.

When the Cray Origin 2000 was installed at the University of Bergen in autumn 1996, it was the first of its kind in Europe, a short-lived distinction at best. The computer had a computational capacity that was almost unparalleled, allowing researchers to perform calculations hardly anyone had been able to make earlier.

The "Computational Science Programme 1999–2003" will be carrying the Research Council of Norway's efforts in the field of supercomputing forward in the years ahead.

Number crunching for pharmaceuticals, pollution and the climate

WEATHER FORECASTING is one of the most demanding computational operations done today. Without the supercomputer at the University of Trondheim, Norwegian weather forecasting would hardly have been possible at its current level of detail.

CLIMATE RESEARCH is a field in rapid growth. One important part of climate research involves studying the extent to which man influences the climate. Climate researchers are high-volume users of supercomputers.

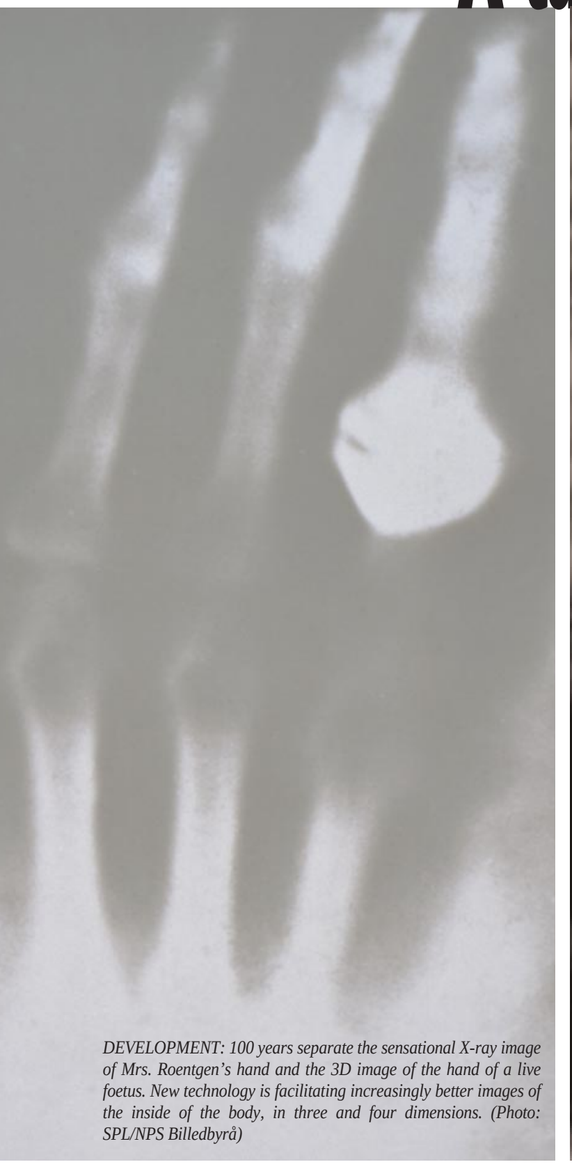
AIR POLLUTION in cities such as Oslo and Bergen is a serious problem in the winter months. Ordinary monitoring stations can report pollution levels at any given time, but it takes supercomputers to forecast urban pollution levels a day in advance.

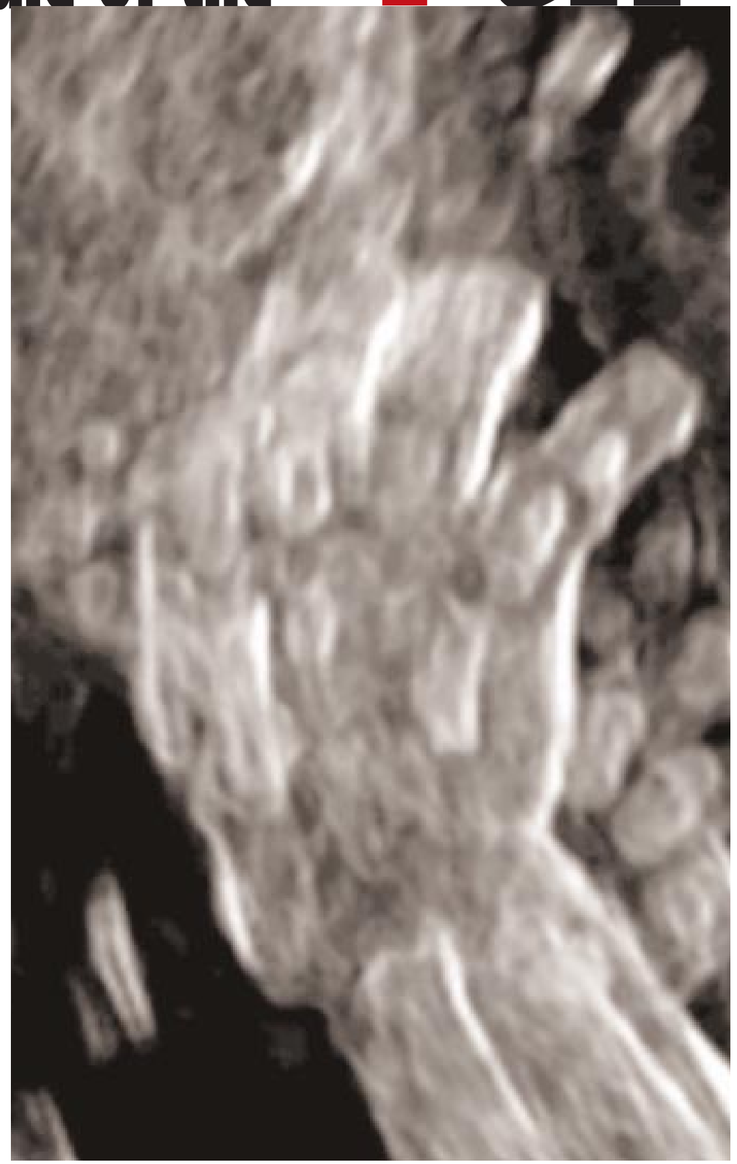
OCEAN CURRENTS in the North Sea have been charted in more detail than ever before by a graduate student in Bergen, thanks to a calculation of six months' duration (!) he did on the supercomputer at the university.

PHARMACEUTICAL RESEARCH calls for the investment of tremendous resources. A research group in Tromsø has used the university's supercomputer to make sophisticated models to determine how drugs will affect the body.

SUPERCONDUCTORS is a field of basic research with an immense potential. A group of physicists at the University of Trondheim has taken an impressive leap forward by making new discoveries about the factors that impede superconduction.

A tale of the 4th dimension





DEVELOPMENT: 100 years separate the sensational X-ray image of Mrs. Roentgen's hand and the 3D image of the hand of a live foetus. New technology is facilitating increasingly better images of the inside of the body, in three and four dimensions. (Photo: SPL/NPS Billedbyrå)

Super sophisticated ultrasound technology is revolutionising medical diagnostics and treatments, opening up exciting new horizons: Imagine, 3D images of the heart and circulatory system as seen from the inside, virtual brain operations and full overviews of organ development in foetuses as tiny as nine millimetres in size while still in the womb.

BY MONA GRAVNINGEN RYGH

In 1895, the picture of the X-rayed hand of Wilhelm Conrad Roentgen's wife Bertha created quite a stir, and the X-ray image with the ring on the finger is widely known. Today, large parts of the world have become so blasé when it comes to technology that many people may not even be surprised by a 3D image of the hand of a living foetus. The latest developments in ultrasound instrumentation, digital image processing and visualisation techniques entail that 3D images of the inside of the body can be used for several applications, including diagnostics, research and non-invasive surgery.

The technique involves converting ultrasound images into 3D volumes. It facilitates the imaging and analysis of structures and pathologies with complex geometries. Vingmed, an enterprise located in the small Norwegian town of Horten, has been actively engaged in research on ultrasound visualisation since 1985, focusing strongly on 3D ultrasound images since 1990. The company has established unique co-operation with many research institutions in the area of IT and image processing, as well as with clinical communities. These efforts have put Vingmed in the vanguard of technical and clinical testing in respect of this exciting imaging modality.

A PIONEER: Bjørn Olstad, Vingmed's director of research. (Photo: Mona Gravningen Rygh)

ADVANCED TECHNOLOGY

"Vingmed's main expertise is cardiology", explains Research Director Bjørn Olstad. He himself has played a key part in designing the algorithms for the type of image processing with which the company works. He was appointed professor at the Norwegian University of Science and Technology in 1993 at the age of just 29, with image processing as his speciality. The university's collaboration with Vingmed subsequently led him to accept an offer to become the company's director of research.

"The three-dimensional ultrasound recordings of the heart are accomplished by guiding a mechanical or electronic ultrasound probe through a spatial search pattern. A computer follows the movements, automatically taking numerous pictures from every position, synchronised with the heart rate. The huge set of original pictures is then converted into a set of volumes", he explains.

"After this spatial conversion, the computer can be used to simulate the placement of the probe. This allows us to use "virtual probes" which can be placed completely independently of where the physical probe was placed originally. In addition, a set of sophisticated image processing algorithms has been developed, making it possible for spatial data to be visualised as an image. The user can choose the calculation method best suited for the clinical problem being treated (surface visualisation or spatial visualisation). This technique has great potential for further applications for ultrasound as a medical imaging modality, both in respect of new applications (for example real time support during heart operations) and in providing more reliable diagnoses in difficult clinical cases", says Olstad.

FROM THREE TO FOUR DIMENSIONS

The next generation of ultrasound systems from Vingmed will be based on digital technology and computer architecture. Applications rendered possible today by post-processing on a computer will be integrated with the scanner, meaning that some computer processing can take place in virtually real time. That is, the imaging is four-dimensional, the fourth dimension being *time*.

"We are also directing research efforts at fields other than ultrasound techniques *per se*. Among them are data processing techniques, image processing, production techniques and functionality", remarks Olstad, emphasising the importance of the company's interdisciplinary collaboration with a variety of Norwegian research institutions.

It takes tremendous computing power to convert ultrasound signals. To manage it, the company has developed its own specialised computers, known as System Five.

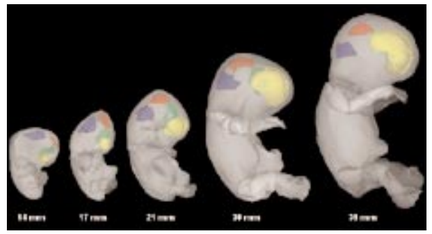
3D WITHOUT MECHANICAL MOVEMENTS

Three-dimensional work is performed in collaboration with a group of researchers from the Department of Informatics at the University of Oslo. In the journal *Diagnostic Imaging*, in 1998, the group's work was described as "Some of the most advanced academic work being done in this field".

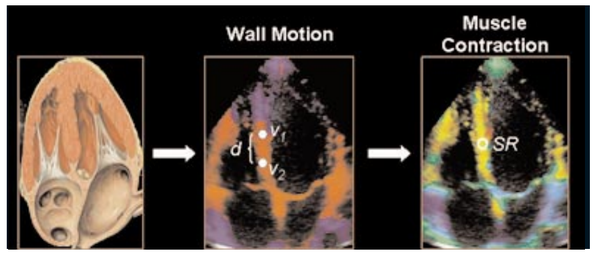
"The goal is to develop the technology needed for real-time data collection and visualisation", explains Professor Sverre Holm, head of the group. "Almost all ultrasound requires that the ultrasound probe be rotated, tipped or moved. It is this movement that facilitates the capture of the third dimension. "The unique aspect of our project is that we are testing considerably more sophisticated ultrasound probes which can guide an ultrasound beam over a volume without any mechanical movement. This also calls for a considerably more complicated ultrasound scanner, but we believe that it will be a reality within a few years, thanks to advances in microelectronics.

The advantage is that we can collect data more quickly, thus achieving a more rapid updating rate on the images. This is what makes it possible to monitor the movements of the heart, for example. Holm adds that this is an EU project in collaboration with Vingmed and Thompson Microsonics of France. In addition, the Research Council of Norway is funding a doctoral fellowship. ▸

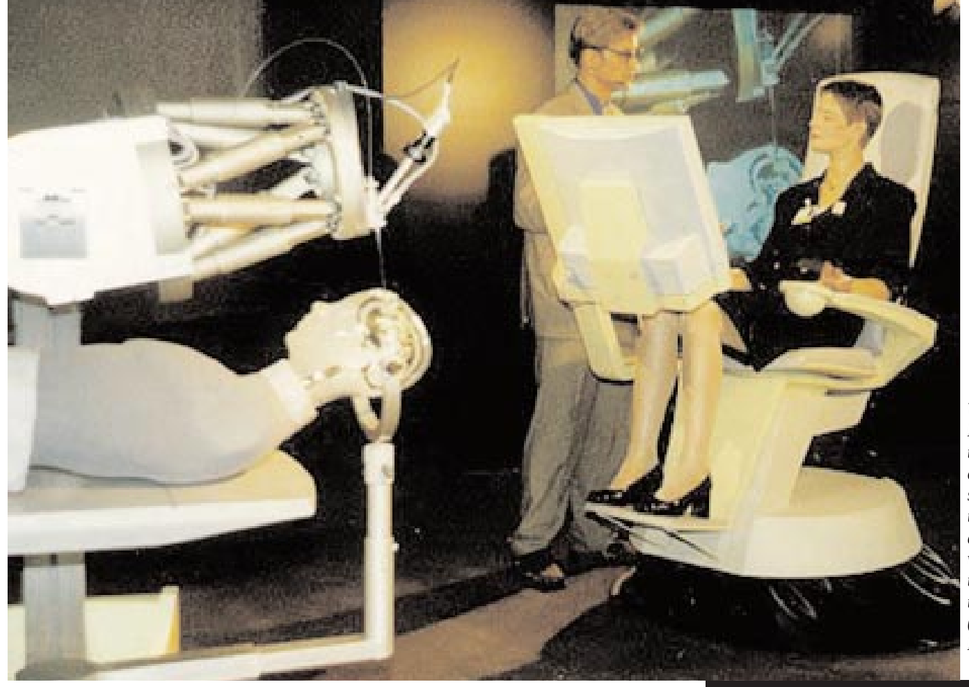
A tale of the 4th dimension



TEENY TINY: Sono-embryology is a new field in which 3D ultrasound images of foetuses down to a mere seven weeks of age allow researchers to learn more about anomalies and diseases among the unborn.



LIVE: This picture illustrates how the results of two new ultrasound imaging techniques can be used to demonstrate how the cardiac muscle contracts. The values produced by these pictures are used to provide objective measurements of how well the cardiac muscle is working. Based on this, it is possible to diagnose what type of coronary disease the patient has.



VIRTUAL SURGERY: In future, it is likely that surgeons will operate using joy sticks while watching ultrasound images on a big screen. Robots will actually perform the operation inside the patient's brain. (Photo: Fraunhofer Institute)

Internet addresses

SINTEF Unimed, Ultrasound Department
http://www.us.unimed.sintef.no/

Department of Computer and Information Science, Norwegian University of Science and Technology.
3D images in the form of a live film showing how the mitral valve of the heart beats, viewed from inside the ventricle:
http://www.idi.ntnu.no/~sevald/stuff/anomal/mitralinsuff030998_1.avi

Three-dimensional visualisation of ultrasound (images)
http://www.idi.ntnu.no/IDT/grupper/AK-grp/presentation/3d-visualisation/

The Data Analysis, Signal, and Image Processing Group of the Department of Informatics of the University of Oslo
3D ultrasound systems (projects):
http://www.ifi.uio.no/~sverre/3dsys.html

More about the projects:
http://www.ifi.uio.no/~sverre/nice.html

MISON - A spin-off company from the Ultrasound Group in Trondheim
http://www.mison.no/

▸ CARDIOVASCULAR DISEASE

The use of ultrasound for diagnosing cardiovascular diseases spares patients from invasive procedures and considerable discomfort. Using Vingmed's equipment, the Norwegian cardiology professor Liv Hatle, ably assisted by the doctors and engineers who worked with her in Trondheim, laid the foundation for ultrasound diagnostics based on blood flow measurement. The method is invaluable to modern medicine for diagnosing heart disease as well as diseases of other organs. Hatle is internationally recognised for her research (see *Tell'Us* no. 2/99).

Ultrasound machines that measure blood flow velocities are based on a phenomenon known as the Doppler effect which takes advantage of the fact that sound frequencies are altered when sound is reflected off a body in motion. Liv Hatle demonstrated how the Doppler effect could be used to diagnose heart valve abnormalities and to assess pressure conditions in the heart. The genius of it is that she made it possible to perform these examinations non-invasively. The doctor simply places a sensor on the skin, and the results can be seen instantly on a screen.

STRESS ECHO

"For the past three years, we have been working on a Research Council project to develop a new technique for stress echoes, an ultrasound technique used for diagnosis and risk assessment of patients with known or suspected coronary disease. Interpretation is based on a visual comparison of the heart's movements at rest and under stress. We have now developed automatic, objective measuring techniques, and the results indicate that we have achieved a high level of quality assurance for this type of examination", reports Olstad. He adds that Liv Hatle, who is now working at the University Hospital at Leuven, Belgium, is a key figure in the clinical testing of the new technique.

New techniques have been developed for visualising blood flows, as have techniques for imaging the contraction of the cardiac muscle. Studies of patients indicate that the new techniques will increase the sensitivity of early diagnoses, providing an important new tool for cardiologists.

FOETAL DIAGNOSTICS

Embryology used to be based on aborted foetuses, but now these soon-to-be people can be studied *in utero*, that is, while they are still in the womb. Norway is on the cutting edge when it comes to using this new technology for embryonic research, so-called sono-embryology. This represents yet another important new application for Vingmed's technology. Three-dimensional ultrasound images of foetuses down to seven weeks of age have been developed by the National Centre for Foetal Medicine at the University Hospital in Trondheim. The foetuses are a mere nine to 40 millimetres long.

"With good 3D images, the doctors can learn more about foetal anomalies, and make presentations of organs while they are developing incorrectly", says Professor Sturla Eik Nes, a specialist in foetal medicine and head of the centre. He explains that these new opportunities are a result of interdisciplinary collaboration among doctors and computer engineers, while Vingmed is responsible for making the machine. Vingmed has set up a special team to work in close contact with the National Centre for Foetal Medicine.

VIRTUAL BRAIN SURGERY

Brain surgeons will soon be able to operate while their eyes are fixed on a computer screen rather than on the patient's brain. Using new ultrasound technology, surgeons can now get 3D images of the brain during an operation. "Virtual reality" technology will make it possible for surgeons to be "present" inside the body, making it easier to navigate through complex structures.

The method is now the object of intensive research and development at the University Hospital in Trondheim, the Norwegian University of Science and Technology and the research institute SINTEF Unimed, in collaboration with commercialisation partner Mison, with support from the Research Council of Norway, among others, and based on equipment from Vingmed.

Traditionally, the surgeon locates the area on which he or she will operate using magnetic resonance images (MRI). They are of excellent quality, but cannot be updated during the operation. The general manager of Mison, Åge Grønningsæter, explains that brain surgery usually entails shifts and changes in the brain, meaning the MRI images become outdated very quickly. Using ultrasound, it is possible to record 3D images in just minutes, keeping up to date with changes as they occur. It is also possible to record live, 2D images at any time during an operation. Ordinarily, the surgeon will make a tiny additional hole in the cranium to get good pictures of the brain, while the procedure itself is performed through another hole. The surgical instruments can be guided using the ultrasound images", expounds Grønningsæter.

BETTER QUALITY OF LIFE

Professor Geirmund Unsgård of the University Hospital in Trondheim is a pioneer when it comes to using ultrasound for brain surgery. "Once the equipment is commercially available, it will be possible to improve the quality and safety of brain surgery. What is more, it will be possible to operate on some patients who are inoperable today. We also expect that the technique will improve the quality of life for many of our patients, reducing hospitalisation and recovery time. For many patients, the technique will lead to more radical surgery of malignant brain tumours, thus increasing their expected survival time", reports Unsgård.

Vingmed

GE Vingmed Ultrasound is an international supplier of ultrasound hardware and software for medical purposes. The enterprise is a European market leader in the field of advanced ultrasound equipment for cardiac examinations based on measuring blood flow in the heart. Intensive research is now in progress on the use of 3D ultrasound imaging, at the same time as efforts are being directed towards eliminating the time lag engendered by acquisition and data processing.

Since it was founded in 1985, Vingmed has co-operated closely with the Department of Physiology and Biomedical Engineering at the Norwegian University of Science and Technology in Trondheim. The company actually has its own seven-member research team affiliated with the department. Vingmed also has a research department with a staff of five in Oslo, where it collaborates with a number of other research institutions. Over the past 10 years, Vingmed has spent 16 to 20 per cent of its sales revenues on research and development. Thus far, more than 50 doctoral theses based on Vingmed's technology have been written in the fields of medicine, natural science and technology. The Resarch Council has supported Vingmed every step of the way, not least trough PROGIT, The Research Council's ICT product commercialization programme.

Vingmed was acquired by General Electric in 1998. Most of the enterprise's 170 employees are located at the main office in Horten, Norway, from where the company serves a global market. Of the company's aggregate sales of about MNOK 750 in 1999, approximately 60 per cent went to Europe, 15 per cent to Asia and 25 per cent to the USA. Sales in the USA are rising rapidly, largely as a result of becoming part of the General Electric Corporation.

In 1995, Vingmed won the EU Commission's ITEA (Information Technology European Award) Grand Prix for System Five. The enterprise was one of three winners in a competition that included 650 leading European technology enterprises. The prize, a gold trophy and ECU 200 000, is awarded to companies that have most successfully used modern information technology to develop commercial products.

PROJECT MANAGERS: Three of Vingmed's research project managers pictured with the prototype for the advanced System Five. Left to right: Håkon Høye (ultrasound probes) Reidar Christiansen (the CardiAssist project, 4D), and Erik Steen (3D visualisation). (Photo: Mona Gravningen Rygh)

Runes and Christianity

• The runes are a Germanic alphabet believed to have originated at about the time of Christ's birth. The oldest runic alphabet consisted of 24 signs and is called "the elder Futhark", after the first six letters in the alphabet ('th' was one letter).

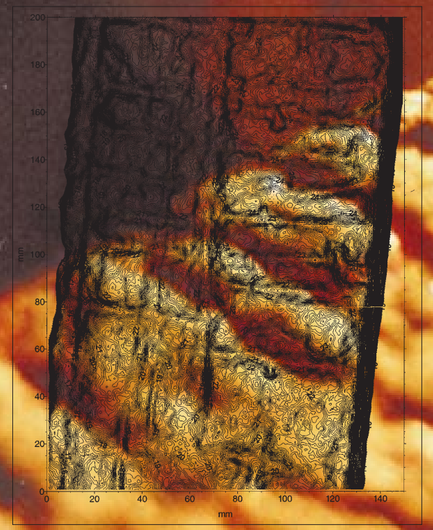
• In about 700, the aboriginal Nordic alphabet was replaced by a new one, the younger Futhark, with just 16 letters.

• The Viking expeditions ended in approximately 1050. At about the same time, Norway was united into a single kingdom, and Christianity was introduced. The Latin alphabet was introduced via England, accompanying Christianity. Runes existed parallel to the Latin alphabet quite far into the Middle Ages, then gradually disappeared from use.

You can't get blood out of a stone, or can you?

Lasers and micro-surveying equipment have put a new face on inscriptions etched into rune stones a millennium ago.

BY ARILD HOKSNES, GEMINI



ORIENTEERING INTO THE PAST. A contour map of the inscription on the Kuli stone. The runes in the ancient inscription look like elevations on an orienteering map. (Illustration: Jan O.H. Swantesson)

DIVULGING NEW SECRETS: The Kuli Stone was erected by Tore and Hallvard on the island of Smøla nearly 1000 year ago. (Photo: Jens Søraa, Gemini)

The Kuli Stone, a rune stone inscribed about 1000 years ago and discovered on the island of Smøla in the 1800s, has taken its own sweet time to divulge its story. Mentioned in the writings of a Norwegian minister in the 1860s, the stone seems subsequently to have sunk into oblivion. Even when the stone was turned over to the Norwegian Museum of Science in 1913, no one showed any particular interest in the inscription. Then in 1956 the stone was 'rediscovered' by a man named Aslak Liestøl. The researcher's astonishment was great when he realised the stone actually represented the oldest known occurrence of the country name "Norway" in writing.

The 1956 examination disclosed that Christianity had been in Norway for twelve winters when the stone was erected, and the inscription stated explicitly that it had been erected by Tore and Hallvard. Years passed. Then one mild evening in 1998, the Kuli Stone divulged another secret. Runologist Jan Ragnar Hagland turned to a physical geographer who had laser and micro-surveying equipment, Dr. Jan Swantesson. As a physical geographer employed by Karlstad College, Dr. Swantesson has spent a tremendous amount of time trudging about in Swedish bogs with his home-made equipment which consists of a frame equipped with a laser, an electronic control unit, and a laptop computer.

MOUNTAINS A MILLIMETRE HIGH

One gets an idea of the accuracy of this system when hearing that Dr. Swantesson intended to survey deviations less than 1-millimetre high on the surface of the Kuli Stone, just as he has done out in Swedish fields and forests to record the deterioration of cultural artefacts. Slowly, infinitely slowly, the laser recorded the minute height differences on the surface. The result will be a map ostensibly indicating valleys and mountain peaks. The only difference is that this map measures highs and lows in tenths of a millimetre.

Professor Jan Ragnar Hagland of the Norwegian University of Science and Technology (NTNU) in Trondheim follows along enthusiastically. He is looking forward to an objective new reading, as he calls it. As the plotter finally begins, he throws himself over the map of the runic inscriptions on the Kuli Stone.

"This confirms what we've always believed: 'Tore and Hallvard erected this stone…'."

The text is readily legible, even though it is covered with red writing. The top of the Kuli Stone is missing; it was probably used to build a barn bridge centuries ago. Up towards the fracture, runologists have interpreted the runes to say: "…after Ulvljot". In other words, the stone was believed to have been erected in memory of a man named Ulv or Ulvljot. A few researchers have let their imaginations run wild, envisaging a noble warrior behind the name.

"No, that can't be right. There are five runes, but they can't mean Ulv or Ulvljot.

"Should we cross him off our list, then?" asks Swantesson.

"I would say so", replies Hagland.

HAGLAND LETS THE FACTS SINK IN

"No doubt about this, though. This says 'Christianity'. Fantastic! The stone actually mentions Christianity", shouts Hagland. Then doubt rears its ugly head; earlier readings have interpreted the whole sentence to read: 'Twelve winters had Christianity been in Norway'. However, deep in one of the valleys, Hagland finds runes that indicate otherwise.

The reading of what's called line B appears to justify a significant change in linguistic content. The crux of the matter is the reading of runes 27 to 31 as *um rit* rather than *uirit*.

"An interpretation of line B according to the new reading may then be: 'Twelve winters had Christianity improved things in Norway or perhaps even 'Twelve winters had Christianity secured law and order in Norway. The new reading of line B in particular seems to strengthen our impression of the inscription as a monument of missionary propaganda for the new faith at an early phase of the Christianisation of Norway", concludes Professor Hagland.

At the core of climatic change

Many wonder whether today's unstable climate is anthropogenic, that is, caused by man, or whether it is due to the whims of Mother Nature. Scientists may find some of the answers to that question on the seabed where organic and inorganic residue builds up layers of sludge year by year. In stable sea areas, the layers can be traced thousands of years back in time.

BY INGAR MYKING

The sludge and sediments along the path of the Gulf Stream and in the fjords along the west coast of Norway contain detailed information about past climatic changes. In summer 1999, researchers took a large number of samples from the seabed. Over the next two years, examinations of the samples are expected to shed some new light on the climatic changes the world is experiencing today.

Thanks to technology carried by the French research ship, the Marion Dufresne, sediments can be used as a chronological archive of climate-related information, facilitating the reconstruction of climatic trends over several thousand years. Today's researchers are able to detect temperature variations of as little as plus/minus one degree through several ice ages (several hundred thousand years).

"To be able to say anything about climatic change today, we need to know as much as possible about the reasons for earlier temperature fluctuations. We now know that rapid, natural changes in average temperatures have occurred previously, with fluctuations of as much as five to ten degrees in as little as a decade", explains Eystein Jansen, professor of paleoclimatology at the University of Bergen. Along with Professor Laurent Labeyrie of the French university Paris-Sud, Orsay, Jansen co-headed part of the Marion Dufresne expedition along the Gulf Stream from the Caribbean to the coast of northern Norway.

BLESSED BY THE GULF STREAM

The climate along the coast of Norway is exceptionally mild, considering its proximity to the Arctic. The reason is the Gulf Stream, which carries warm water from the Gulf of Mexico to the Norwegian coast, making it possible for people to enjoy a dip in the briny deep at latitudes which otherwise lend themselves best to icebergs. That being said, over time, temperature and climate are determined by a more complex global network of variables, and even the Gulf Stream is influenced by the atmosphere and the location of high and low pressure systems.

"We don't know what it would take to disrupt the Gulf Stream, but it is part of an extremely sensitive system. We have recorded small temperature fluctuations in recent years. However, we don't know whether they are due to natural climatic fluctuations or are harbingers of lasting changes. It is still too early to tell", says Jansen. ▸

DANGEROUS CLIMATE: Several houses were reduced to fire wood when the River Moksa in southern Norway changed its course 2 June 1995 during the country's worst flood since 1789. Climatic researchers are investigating whether the on-going climatic changes are natural or man-made. (Photo: All Over Press)

▸ In this sense, the waters off the Norwegian coast are a key area for learning more about fluctuation patterns in the climate and ocean currents. “Here, it is possible to study the Gulf Stream’s transport of heat. The sediments on the fjord floors and on the slope of the Continental Margin are particularly good places for studying these phenomena”, continues Jansen, who expects the research expeditions to produce a detailed new picture of how the oceans affect climatic change.

ATYPICAL TIMES

“In the long term, we hope to collect enough data to form a solid foundation for saying something about whether today’s climatic changes are natural, man-made, or both”, says the professor from Bergen.

The debate regarding the reasons for today’s unstable climate have revolved around the greenhouse effect, the influence of sunspots, cosmic radiation, major volcanic eruptions, etc. Several researchers have recently questioned whether or not most of the blame should to attributed to man-made pollution. Jansen is of the opinion that there are indications that our current climatic situation is different from those of earlier times. Using climatic data, it is possible to make a graph showing temperature trends over past millennia. Against that type of historical timeline, our own era is atypical”, continues the professor.

The Marion Dufresne is the only research ship in the world able to take continuous sediment core samples up to 60 metres long.

“The French have developed highly sophisticated sampling equipment. This field needs huge, stable vessels to collect samples that show sufficient detail”, adds Jansen.

MAKING THE RESULTS PUBLIC

“Norwegians have considerable expertise in analysing sediments from the fjords and the Continental Shelf. As a result, our groups make a good team which is helping to glean more knowledge about climatic fluctuations, not least at the international level”, says Professor Labeyrie.

Jansen’s paleoclimatological research has attracted international attention, and his group has published its results in the prestigious scientific journal *Nature* on several occasions over the past few years.

Altogether, Jansen and Labeyrie managed to collect a kilometre of core samples. The scientific analyses will be performed on terra firma over the next two years. After that, all the sample material will be made available to the public.

International co-operation

In the summer of 1999, the Marion Dufresne made its fifth consecutive annual expedition under the auspices of the French Polar Institute (IFTRP). On two legs of the voyage, the vessel carried researchers from seven or eight nations, including a total of 20 Norwegian graduate students and researchers from the Norwegian Institute of Polar Research, the university courses on Svalbard and the universities of Tromsø, Bergen and Oslo. Most of the Norwegian funding was provided by the Research Council of Norway.

“Norwegian and French experts have been decisive for getting the vessel to our coastal areas, and for obtaining joint international funding. In this context, by virtue of support and guarantees, the Research Council has played a vital part in facilitating the expeditions”, states Professor Eystein Jansen emphatically.

The expeditions are part of an international programme entitled IMAGES (International Marine Global Change Study), which is, in turn, part of Past Global Changes (PAGES) related to the international research programme Global Change (IGBP).

Climatic complexities

Over the past century, average temperatures have risen in Norway and globally. Nonetheless, Norway is in a class of its own. While the 1990s was the warmest decade from 1860 to 1999 on the global level, average temperatures in northern Norway were just as high in the 1930s as at the end of the 20th century.

BY SIW ELLEN JAKOBSEN

In certain years, there were clear differences between average global temperatures and those in Norway. Globally, for example, 1998 was the warmest year ever recorded using reliable temperature measurements, but it was a normal year in Norway. Here, nearly half the years since 1900 have had higher or equally high annual mean temperatures as 1998.

“The annual mean temperature has increased by about 0.7° C over the past 100 years on a global basis, and the annual mean temperature has increased by between 0.5 and 1.0° C in most parts of Norway. The special thing about Norway is that average temperatures in parts of northern Norway and on the Svalbard archipelago were as high in the 1930s as they are today”, observe climatologists Eirik Førland and Inger Hanssen-Bauer at the Norwegian Meteorological Institute (DNMI) in Oslo. The researchers are participating in the Research Council’s project Regional climate development under global warming (RegClim).

REGIONAL CLIMATE MODELS

Norway is an exciting, but complex country in terms of climatology. The country’s varied topography means that the global climate models developed for international use are not particularly suitable for Norway’s climatic trends. RegClim climatologists are in the process of developing regional climate models that can predict something about Norway’s future climate, based on global climate models and regional meteorological data.

It can be raining heavily for days on the west coast of Norway, while it is clear and sunny in Oslo in the eastern part of the country. Such variations are not captured by the huge global climate models, which, among other things, do not have particularly good terrain resolution. These models produce useful results on a large scale, but are not useful for forecasting climate changes in specific areas, for instance, Norway. However, by examining historical climate data, it is possible to find correlations between large-scale and local climates.

As the global climate changes, RegClim participants will be trying to predict the most likely regional climate development trends in Norway. It appears that temperatures in northern Norway have increased in the spring and summer, while those in the southern part of the country have increased in the spring and autumn. The high annual temperature in the 1930s was the result of high temperatures in the winter, summer and autumn. In recent years, mild winters have been the main explanation for the rise in average annual temperatures.

IT’S RAINING, IT’S POURING …

Most places in Norway have noted a marked increase in precipitation levels over the past century, although the scope of the increase differs considerably from one part of the country to the next. North-western Norway has seen the most significant increase. There are also pronounced regional differences in the seasons experiencing the increase: northern Norway has noted increases in the spring and summer, while southern Norway has recorded the greatest increases in the autumn. Winter precipitation has also increased significantly in most parts of northern Norway.

Also globally, there has been an increase in precipitation, especially in the northern hemisphere where precipitation has climbed by 10 per cent over the past 100 years. The increase has been particularly pronounced in the Norwegian part of the Arctic, (Spitsbergen, Bjørnøya and Jan Mayen), where precipitation levels are as much as 25 to 30 per cent higher now than at the beginning of the 20th century.

GREENHOUSE EFFECT

Climatologists ascribe the rise in precipitation in some areas of Norway to more frequent or stronger winds from the south-west. They have, in fact, found that a large part of the change in temperature and precipitation is related to systematic fluctuations in the pattern of atmospheric circulation over northern Europe. These changes may be attributable to the growing severity of the greenhouse effect.

The temperature increases noted in our areas over the past 20 years are probably due in part to global emissions of greenhouse gases. However, the global rise in temperatures during the early half of the 1900s is difficult to explain fully using the global climate models developed to simulate climate trends caused by an increase in the greenhouse effect. Nor can the temperature rise in Norway during this period be explained solely by changing circulation patterns. This demonstrates the importance of long-term studies to climate research, according to Førland and Hanssen-Bauer.

THE CLIMATE OF TOMORROW: The first climate scenarios indicate that Norway will be experiencing warmer winters and wetter autumns. (Photo: Samfoto)

Milder winters in Norway

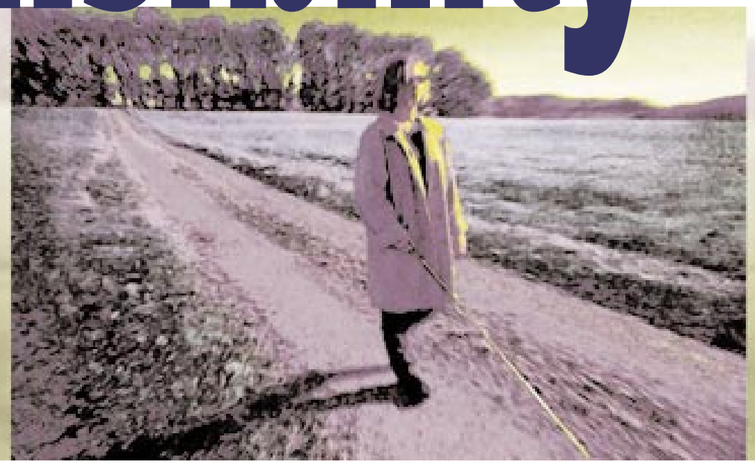
Norway’s future climate is expected to feature milder winters and wetter autumns, according to the first climate scenarios presented by Norwegian researchers. In December 1999, the researchers involved in RegClim presented their first forecasts for climatic and weather conditions in Norway in the decades ahead. Eirik J. Førland and Thor Erik Nordeng emphasise that their calculations are still subject to a great deal of uncertainty, and that they expect the models to improve considerably. With that proviso, they presented the following main conclusions about the period from 2000 to 2050 in a newsletter from the Cicero Research Foundation:

- If atmospheric concentrations of greenhouse gases continue to increase, average annual temperatures in different parts of Norway are expected to rise by 0.2 to 0.7° C. per decade;
- Temperature increases are expected to be most significant inland, and least along the coast;
- All seasons will be warmer, but winters will see the most significant rise;
- Svalbard and the Barents region will probably experience the greatest temperature increase;
- Annual precipitation will rise in most parts of Norway, but most in the western part of the country;
- The rise in precipitation will be most pronounced in the autumn, except in eastern Norway;
- Eastern Norway will probably receive less precipitation in spring, while the greatest increase will be in winter.

Senses and sensibility

Can you imagine a talking speech prosthesis for someone without a voice, or a listening prosthesis that can translate speech into text for a deaf person? What about a personal navigation system to help a sight-impaired person know where it is safe to step off the pavement? Information technology is opening up a tremendous range of possibilities for the physically challenged.

BY ANNE-LISE AAKERVIK, GEMINI



A RANGE OF POSSIBILITIES: Information technology is opening up new possibilities for the physically challenged. Now, speech-based navigation systems are being developed to help blind and sight-impaired find their way around.
(Photo: Rune-Petter Ness)

There is a 20-year-old girl from Bergen with cerebral palsy. She thinks, sees, hears and writes just as you and I, but, alas, she has no voice. And she would like to have one: "I want the voice of a young women with a Bergen dialect. I want a computer that I can operate with my brain. A computer like that would let me roar when I need to roar; I could talk like everyone else, expressing anger and joy. Maybe I could even whisper, so my mother couldn't hear. I have a lot to say and many opinions, but talking is a long-drawn out process for me."

Few can envisage what it must be like not to have a voice of one's own. Anger, grief, joy and laughter are not the same in writing. But the day is rapidly approaching when language technology should be able to make some of this young lady's dreams come true. Over the next four years, the Research Council of Norway's programme entitled "IT for the disabled" (IT-Funk) will be spending MNOK 25 on the development of user-friendly IT products and services for the disabled.

"As many people as possible should benefit from the progress being made in the field of information and communications technology", says Tron Espeli, an adviser with the Research Council.

UNDREAMT-OF OPPORTUNITIES

Voice recognition software is already on the market, as are a variety of speech synthesis programs. Navigation systems for the sight-impaired are currently in the pipeline, and an electronic memory is being tested for individuals with acquired brain damage (ABD). Certain research groups have made major advances in the miniaturisation of electronics, while others are working on miniature communications equipment that is cordless and battery powered. Such advances will open up a new horizons for the disabled. Many have feared that IT would alienate and isolate vulnerable social groups. This has been a very real concern for the disabled, and justifiably so, since they have usually been at the end of the queue when it comes to the development and adaptation of new technologies and services.

"The goal should be for as many as possible to benefit from the technological advances being achieved in the field of information technology. This should be what drives product development forward for those of us who are concerned about access to user-friendly IT products and services for the disabled", points out Maja Arnestad, project manager for the Research Council of Norway's "IT-Funk", a programme designed to promote IT for the disabled.

TALKING MAPS

The first global positioning systems (GPS) for vehicles appeared on the market years ago. They guide drivers along unfamiliar roads using maps and messages. Similar technology is now being developed for pedestrians, according to Ingrid Svagård of Sintef Telecom and Informatics. She is manager of a project aimed at developing a portable, speech-based system called "Speech Navigator". The system is designed to help the blind and sight-impaired find their way around. Based on electronic maps and a compass, the system features speech-based interaction between the user and the system. Users can determine where they are at any given time, then get directions for the best way to reach their destination. In the digital world, this is known as getting "on-line, interactive information about position, direction and route."

"Demo models have been made in both the US and the UK, but the technology was not good enough, so it undermined user confidence. We need to do something about that", remarks Svagård.

One of the problems remaining to be solved is that GPS users have to be within free range of a GPS satellite. This can be a problem in big cities where skyscrapers can get in the way, sporadically leaving the sight-impaired user with no means of spatial orientation. Better digital maps are needed as well. Once the maps can provide more information about traffic lights and pedestrian crossings in addition to road information, they will benefit more groups of people.

"As time passes, the system will lend itself to other applications, for example, for helping tourists get around in unfamiliar cities", adds Svagård.

ELECTRONIC CONVERSATIONS

Randi and Ole are sitting in a café, talking. Randi is deaf and, although Ole can hear, he has no knowledge of sign language. However, the situation does not appear to be inhibiting their conversation. Randi carries a couple of lapel microphones which she fastens to the lapels of the people with whom she is talking. Thanks to a small device Randi has in her pocket, her conversation partner's voice is recognised and presented as text, either on a hand-held PC, or on a pair of computerised glasses that display a tiny screen in front of one eye.

At the moment, this is no more than a vision of the future, but scientists are getting closer to a solution all the time. Efforts are being made to set up a test service for speaking phones and textphones for the hearing- and speech-impaired.

"Today, a hearing-impaired person who wants to speak to someone who has a regular phone has to ring a manual switchboard service where an operator "translates" text into speech. In future, it will be possible to translate automatically in both directions", explains Georg Ottesen of Sintef Telecom and Informatics.

Speech synthesis takes place when text is keyed in by the hearing-impaired person, then translated into speech by the hearing person's receiver. This requires a voice recognition system with a relatively limited vocabulary, so that the voice of the hearing person appears as text on either a textphone or a PC.

"In addition to recognising speech, it would be a great advantage if it were possible to indicate the way in which words are spoken. For example, anger, laughter or sadness could be conveyed using colours, fonts, underlining and exclamation points", explains Ottesen.

BRAIN IN A BOX

In the not too distant future, people with cognitive disabilities such as concentration, memory and/or language problems will be able to get invaluable help from PCs equipped with the appropriate software. The EU's TASC (Telematics Applications Supporting Cognition) project, aimed at developing such software, is already being tested by different groups of people in several countries. Groups in Northern Ireland, Denmark and Sweden have been asked to examine more closely the potential needs of and applications designed for the mentally handicapped. In Finland, efforts are focusing on patients suffering from senile dementia, and in Norway, people with acquired brain damage (ABD) will be trying out a variety of models. The software is based on daily schedulers. Someone enters all the different tasks to be performed during the day in chronological order on a PC. An alarm will then announce when it is time to start making dinner, for example. It is possible to receive messages in the form of text, sound, images, or a combination of the above.

"Mind you, memory problems are a double-edged sword", smiles Sveinung Tornås at the Sunnaas Rehabilitation Hospital outside Oslo. The systems being developed under the auspices of the Norwegian TASC Project are being tested and verified at the hospital's cognitive rehabilitation unit.

"Our participants have all led normal lives, but they are now subject to many roles/expectation related to the person they were before they were involved in an accident. What's more, most of their faculties are intact. Nonetheless, there are many things they can no longer do due to their cognitive problems. Most of them would like a tool to help them plan and structure their everyday routines", remarks Tornås.

Sunnaas Rehabilitation Hospital: *http://home.sol.no/~kress/English/english_frameset.htm*

Sintef Telecom and Informatics: *http://www.informatics.sintef.no/*

IT-Funk

The Research Council of Norway has been commissioned by the Ministry of Trade and Industry and the Ministry of Health and Social Affairs to draw up a plan for IT for the disabled. The resultant research programme is called IT-Funk, and is intended, among other things, to augment knowledge and awareness of the importance of information technology for the disabled.

"More than any other group, the disabled need the equipment being developed in the field of modern IT and language technology. New tools can make functional disabilities irrelevant in areas where they previously presented an insurmountable barrier to social contact", comments Maja Arnestad, the Research Council's contact in the Industry and Energy Division.

"The truth is that user-friendly products are an advantage for all users, not just the disabled, meaning they will be a good investment. The manufacturing industry simply hasn't realised it yet," Arnestad concludes.

Microscopic machines can be dispatched into the body to repair blood vessels, along with microcameras the size of a grain of sand. There are strong indications that nanotechnology will come to dominate the early decades of the new millennium.

BY PER KRISTIAN BJØRKENG, AFTENPOSTEN

It's a small, small, small world

"Micro- and nanotechnology will become just as important in the years ahead as computer technology has been in recent years. This technology will take science to entirely new levels", remarks Project Director Anders Hanneborg of SINTEF Electronics and Cybernetics in Oslo.

Researchers at this SINTEF institute are currently developing machines so tiny that one needs a microscope to see how they are assembled. In fact, microtechnology is so small that it is based on a scale measured in micrometers, that is, thousandths of a millimetre. And today's researchers are diving even deeper into the microcosmos by moving into nanotechnology, where accuracy is measured in nanometres, that is, thousandths of a micrometer.

50 DOCTORATES

The summer of 2000 will see the start of construction of a new MNOK 200 microtechnology laboratory in Oslo. The Research Council of Norway is targeting this field, and will be providing funds for 50 doctorates over the next five years in this very narrow speciality.

"Every facet of society will be influenced by these minute machines. Norway's National Hospital is already co-operating with the University of Oslo and SINTEF to develop a tiny device to be implanted in the skull of patients suffering from hydrocephaly. When water pressure increases, the sensor will detect it, and release excess water through a drain", explains Hanneborg.

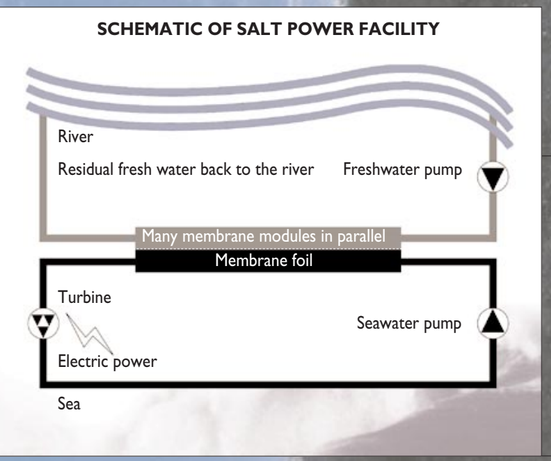
Researchers in a variety of fields are hard at work creating the technology needed to build a machine so small that it can be injected into a blood vessel using a syringe. There, the machine could perform tasks that currently call of surgical intervention, angioplasties, for instance, that is, the unclogging of clogged blood vessels.

The transport sector will also be totally changed. Several years ago, the SensoNor company developed a microsensor that detects collisions, instantly releasing airbags to protect the passengers. The next step will be sensors that communicate with components embedded in the roadway, so cars will navigate themselves, allowing drivers to read the newspaper or enjoy the scenery.

KEYBOARDLESS KEYBOARDING

Like all other technology, it will also be possible to use micro- and nanotechnology for more jaundiced applications. For example, it will be possible to make remote-controlled camera systems and microphones the size of a grain of sand. And development will continue relentlessly, regardless of its potential adverse applications. The main challenge in respect of the new micromachines is enabling them to communicate with the world around them, which will open up an incredible number of potential applications. At the University of California at Berkeley, researchers are attempting to create 'smart dust' that can be attached to fingernails, for example, to detect your finger movements. That would make it possible to enter information into a computer without using a keyboard. In other words, you could send an email from wherever you might be at any given time without having access to your keyboard!

NANOENGINEERING: The computer chip being carried by this minuscule ant is just one of many examples of how far microtechnologies have already progressed. The picture was taken by researchers at Huddersfield University in the UK. (Photo: Reuters)



OSMOSIS: A salinity power plant would be fitted with a membrane enclosed in a container. There would be currents on both sides of the membrane. Freshwater would be flowing on the one side, at the same time as it would be moving through the membrane to dilute the seawater flowing on the other side. Freshwater and seawater would subsequently be mixed in the seawater channel, creating osmotic pressure which would in turn drive a turbine and generate electricity.

With its long coastline and numerous freshwater lakes, Norway has a huge potential for generating power, but its potential may be far greater than previously expected. Research is currently in progress to determine how freshwater, in contact with saltwater, can result in competitively priced, environment-friendly power. Researchers believe that salinity power plants might be an important contribution to Norway's future energy production.

BY SIW ELLEN JAKOBSEN

Salt power

This salt power research project falls under the industrial auspices of Statskraft, Norway's largest national power company. SINTEF (Civil and Environmental Engineering) is managing the project. The Helsinki University of Technology and the Portuguese Research Institute Ictpol are contributing expertise and membranes to the project, which is being financed by Statskraft and the Research Council of Norway's programme for "Efficient, renewable energy technologies" (NYTEK).

WATER, WATER, EVERYWHERE: Norway has a long coastline, numerous lakes and plenty of space. This makes it a very interesting place for investigating how to generate power by bringing saltwater and freshwater together. (Photo: Samfoto)

For centuries, people have known that when saltwater and freshwater are divided into two distinct chambers separated by a semipermeable membrane, a biological membrane made from a pig's bladder, for example, excess pressure will build up, causing the less concentrated solution (freshwater) to dilute the more concentrated one (saltwater) until the two are in equilibrium, that is, until they reach the same concentration. This process is based on a simple principle known as osmosis and the pressure is called osmotic pressure. Norwegian researchers would like to take advantage of this process on a rather grand scale by diverting water from a river into a power plant, where it would meet saltwater pumped up from the ocean. The excess pressure created in the saltwater would be diverted to a turbine and used to generate electricity.

According to the most optimistic prognoses, if researchers succeed, the resultant energy prices could be pressed down towards a mere NOK 0.25 per kilowatt hour. Even better, this type of power generation creates no CO_2 emissions. All in all, salt power could turn out to be a substantial energy resource. Calculations indicate that Norway could produce a total of 20–25 TWh of energy per year with the help of salt power. By comparison, the largest, most modern gas-fuelled power plant can produce three TWh per year.

THE MEMBRANE IS THE KEY

There are, of course, certain criteria which must be met before this type of power production will ever see a breakthrough. Researchers are working relentlessly to develop a membrane that will lend itself to salinity power plants. The membrane has to let the freshwater through easily, while keeping the saltwater contained on the other side. "Herein lies the challenge. We are not sure that we can manage to develop this type of membrane", admits Project Manager Rune Øyan of Statskraft. The membrane would be similar to those used with reverse osmosis for desalination, that is, for removing the salt from seawater to produce freshwater. There are already numerous desalination plants all over the world. "We have tried all the types of membranes currently available on the market, but so far none of them has turned out to be worth what it costs. Membrane prices and durability will determine the price of the energy produced, and whether this energy generation technology will be viable", continues Øyan.

A MEDIUM-SIZED FOOTBALL STADIUM

For financial and practical reasons, a salinity power plant would have to be situated at the mouth of a river, or between the sea and a nearby lake. The project would call for three relatively large-scale water pipes, one for freshwater, one for saltwater and one for brackish water. Brackish water is what forms when freshwater and saltwater mix, and it would be discharged back into the sea again. A 50-megawatt facility would take up the same amount of space as a football stadium if it were built at ground level. "The environmental disadvantages are minimal compared with many other alternatives. This kind of facility would have no significant impact on large wilderness areas, and the method could be adapted to facilities of all sizes", concludes Øyan.

Waste not, want not

Using technology that ensures record-low pollution levels and modest operating costs, Energos' waste-to-energy facility has attracted considerable attention from environmentalists, investors and international energy companies.

BY INGAR MYKING AND BJARNE RØSJØ

In the shadow of the huge paper factory next door, a nondescript little building in Ranheim near Trondheim hides an environmental technology company that seems to be 'burning out' a niche for itself on the export market. This little village is where the energy enterprise Energos built its first, apparently low-key, waste-to-energy facility in 1997. A mere three years later, European energy companies are practically queuing up to sign co-operation agreements.

Energos achieved its international breakthrough in 1998, when the CEO signed a letter of intention to build a MNOK 750 refuse-to-fuel plant in Germany. But that was only the beginning, as the company signed one contract after the next. Now, in 2000, the enterprise has sales and operating contracts for facilities destined for Germany, Portugal, Sweden and Finland. Over the coming decade, the contracts will be worth an estimated NOK 2 billion.

AN OFFER HE SIMPLY COULD NOT REFUSE

The technology *per se* was developed by founder Helge Rosvold at a test facility at the SINTEF Research Foundation in Trondheim. After granting Rosvold financial support for nearly 10 years, in 1994 the Research Council issued an ultimatum, stating in no uncertain terms that the time had come to test commercial potential. In other words, any further assistance would be contingent upon taking the product to market and testing the technology.

"The ultimatum was the incentive I needed. Had the Research Council not been willing to make such high-risk capital available to me, the project would probably never have come to fruition," confesses Rosvold.

THE KEY TO SUCCESS

"What makes your facilities pollute so much less than other ones?"

"The key to success lies in controlling the combustion process. Waste is far from homogenous, so different parts of it require different temperatures to be broken down. By controlling the process, we can optimise energy recovery in the form of steam", clarifies Rosvold. The paper factory next door and the Trondheim sanitation company deliver refuse to the facility. All the energy generated is bought by the paper factory, which used to be oil-fuelled. Emissions are far below the EU standards for incineration facilities. "Actually, what comes out of the smokestack is considerably cleaner than the ambient air", smiles Helge Rosvold. On average, Energos incinerates two tonnes of waste per hour, or 16 000 tonnes per year.

Senior Process Engineer Hans Olav Midtbust adds that operating costs are minimal since each facility only needs two operators on the day shift. All other operations are remote-controlled from an operations centre.

LOOK OUT WORLD!

In addition to its success in Germany, the company is in the process of building energy plants linked to a fish processing plant and a paper factory in Norway, and recently signed an agreement with 34 municipal and inter-municipal companies. "First, we will get 10 or 20 plants up and running in Norway, then we intend to move out into the world!" says Helge Rosvold, who believes it is realistic to deliver as many as 20 units per year.

Energos

Energos develops, builds and operates small-scale power plants based on waste-derived energy recovery. The company applies technology based on a waste incinerator that results in exceptionally low levels of pollution. All combustible waste can be converted into energy in the form of steam, hot water or electricity.

Energos engenders double environmental dividends: it helps reduce the tip volume of waste and the environmental problems such waste entails in terms of methane emissions, etc. Energy based on fossil fuels will increasingly be replaced by various types of alternative energy sources. The Norwegian authorities wish to encourage this trend towards energy switching. The application of Energos' waste-derived energy recovery technology is a prudent financial investment at the same time as its emissions are well within national and international pollution control limits.

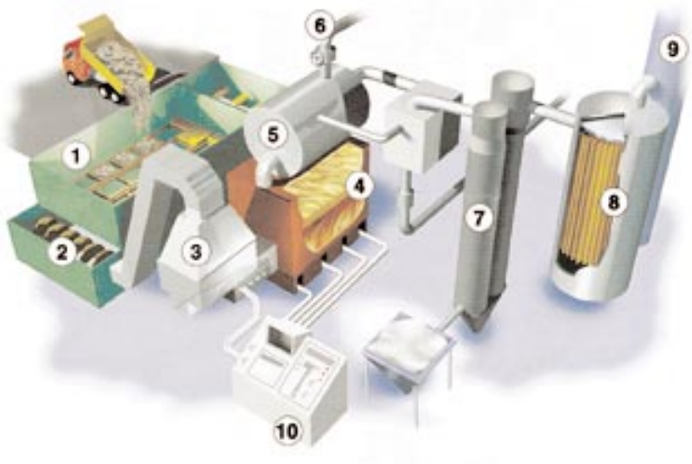
> "Operating a power plant that generates 10 MW of electricity calls for the incineration of about 30 000 tonnes of refuse."

Efficient, renewable energy technologies

The Research Council of Norway helped finance the project through the NYTEK programme which aims at supporting R&D on efficient, renewable energy technologies. The programme focuses on development up to prototype testing. For the purposes of the programme, the term 'renewable energy' chiefly refers to solar, bio-, wind, geothermal and wave energy. Other renewable energy sources such as ocean currents and salinity gradients, as well as micro hydropower plants, may also qualify for NYTEK. The programme is intended to concentrate on areas with commercial potential for Norwegian enterprises. Special emphasis is attached to high-risk projects and projects with major domestic wealth creation potential.

> "There are approximately 400 million people living in western Europe. Each year, they produce a total of 200 million tonnes of combustible waste."

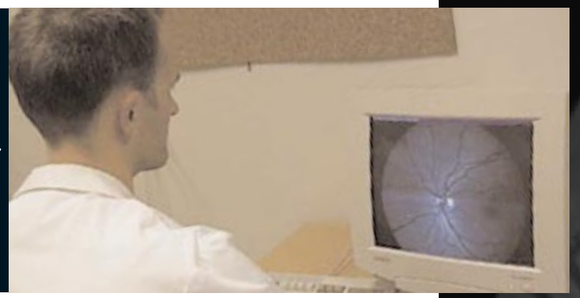
ENERGY TO BURN: There are tremendous amounts of energy in this garbage. The energy can be released through combustion, but that causes pollution. Hence it is necessary to control the incineration process. (Photo: Samfoto)



THE ENERGY RECOVERY PROCESS:

1 The fuel is ground up and deposited in a silo.
2 The fuel is transported to the fuel magazine.
3 The fuel is added to the furnace in portions as needed.
4 The fuel is mechanically shovelled over a grid in the primary chamber of the furnace. Combustible gases are burned in the secondary chamber.
5 The flue gas is then channelled into a boiler where it is cooled down to steam.
6 Energy in the form of steam.
7 The flue gas goes to a reactor where calcium and active carbon are added.
8 A filter removes dust particles, calcium and active carbon from the gas.
9 The cleaned flue gas is released from the smokestack into the air.
10 The entire process is controlled by an innovative new control and monitoring system so the facility operates optimally, satisfying all environmental requirements.

EMAIL DIAGNOSES: Here, a diabetic is being screened for diabetic retinopathy at a local hospital. A nurse takes a picture of the back of the patient's eye, then sends it by email to an opthalmologist at the Regional Hospital in Tromsø. (Photo: National Centre of Telemedicine.)



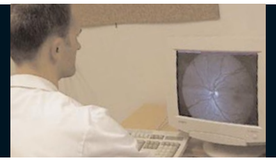
ACCURATE DIAGNOSIS: Opthalmologist Kristian Fossen receives a picture from a local hospital by email. The picture has such high resolution that he is able to diagnose the patient's problem just as accurately as if the patient had been in the same room. (Photo: National Centre of Telemedicine.)

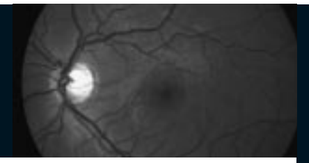
More health IN EVERY BYTE

Today, northern Norway is the world's most sophisticated telemedicine laboratory. In a region where patients and medical experts are separated by vast geographical distances, regional disadvantages have been turned to advantages.

BY SIW ELLEN JAKOBSEN

More health IN EVERY BYTE





Nowadays, a person living on the Russian border in Finnmark, Norway's northernmost county, can be remotely diagnosed by highly qualified medical experts from the peace and quiet of her own home. Using an ordinary PC equipped with a modem to facilitate contact with the Regional Hospital in Tromsø, the patient no longer needs to travel 800 km to get an accurate diagnosis. This part of Norway is frequently at the mercy of difficult travel conditions and there is a scarcity of public health personnel.

Steinar Pedersen, head of the National Centre of Telemedicine at the Regional Hospital in Tromsø, feels the system provides a glimpse of what the patient's role will be like in the future. Telemedicine gives patients more freedom and more power: "Why spend hours or days getting to the doctor when modern technology makes it possible to have routine check-ups and tests straight from home?"

HEALTH ON THE INTERNET

For the most part, telemedicine is used for remote consultations and diagnoses aided by sound/image communications, and the patient and physician are present at the same time. Consultations with specialists usually take place in the presence of a doctor or nurse at a local doctor's office or at a local or regional hospital. From there, it is possible to communicate with specialists located somewhere else who pose diagnoses or offer advice regarding further treatment.

Several groups of patients have expressed the desire for home health services, for example, expectant mothers, cancer patients, elderly people and those who have chronic diseases such as diabetes, asthma and epilepsy which call for frequent visits to the doctor. Surveys among patients indicate that if given a choice between visiting the doctor and using telemedicine from home, most patients would prefer the latter. To cut down on the number of days they have to spend in the hospital, a number of elderly patients in northern Norway have already been equipped with videophones upon being discharged.

Steinar Pedersen believes the standard will move increasingly in the direction of Internet-based solutions. "Internet technology will be the catalyst for a dramatic increase in what might be called 'seamless' communications. This will form the backbone of telemedicine services for many years. At the moment, however, there are organisational, technological and legal impediments to offering open networks. At present, we generally work on a closed network to which patients do not have access.

DEMOCRATIC MEDICINE

Internationally, telemedical services are experiencing exponential growth. The most advanced countries are the USA, Canada, Australia, Israel and the countries of western Europe, including those in the Nordic region. Concerted international efforts are currently being made to develop telemedicine concepts that can compete with the Norwegian solutions. However, northern Norway is among the world leaders.

According to Steinar Pedersen, northern Norway is so far advanced because Norwegian politicians have been receptive to innovation in this field, placing Norway among the world elite in terms of developing telemedicine technology. "We also have a sparse, exceptionally widespread population, a factor that might initially be viewed as a disadvantage. However, broad political consensus about maintaining settlement in outlying areas and a political decision to ensure that patients have equal access to health services regardless of where they live has turned Norway's settlement pattern to our advantage. Telemedicine will be a critical tool in the efforts to achieve the ambitious goal of making public health services available to everyone", confirms Pedersen, who also believes that telemedicine may help remedy the recruitment problems experienced by the public health system, since it will reduce the professional isolation felt by many doctors working in peripheral areas.

Norway's former Minister of Health, Dagfinn Høybråten, hopes telemedicine will help increase the efficiency of the public health system by relieving doctors of some routine administrative work. "Today, Norwegian physicians spend about 600 man-years of labour filling in forms. Had these physicians been allowed to focus exclusively on what they were trained to do, every vacant doctors' position in Norway would have been filled," said Minister Dagfinn Høybråten at the Telemed ´99 Conference organised in Tromsø last autumn.

COST EFFECTIVE

In Pedersen's opinion, telemedicine is cost effective in most municipalities in Norway. Health economy analyses indicate that it is the patient base which generally determines whether telemedicine is more profitable than having a patient visit a specialist or vice versa. In fact, studies have shown that telemedicine is the most profitable solution for services such as teleradiology, telederматology and teleendoscopy.

Telemedicine affects the finances, organisation and administration of the established public health system, and it is not yet clear exactly who is responsible for what. "One major problem is that those who invest in the equipment for telemedicine are not the ones profiting from it", Pedersen says. "Equipment costs seem high to the municipalities, constituting a barrier to the establishment of telemedicine. What the state 'saves' on the reimbursement of travel expenses for patients is not passed on to the municipalities or doctors. We have to figure out how to co-ordinate the various public administration levels to make it easier to finance telemedical equipment."

Not only are there organisational and financial barriers to the development of telemedicine, there is also some uncertainty attached the legal issues. "The various telemedical methods differ so widely that it is difficult to draw up a general assessment of the legal situation. The legal advisers at the National Centre of Telemedicine are now working on incorporating quality assurance into the areas of telemedical practice which are subject to legal issues", continues Pedersen.

BOUNDLESS

In principle, telemedicine has no natural geographical borders. The network currently in the process of evolving will eventually be global. This means that specialists can be anywhere in the world, totally independent of patient location, as long as both parties have access to the requisite technology.

Combined with favourable price trends for telecom services, technological developments will make it possible to transfer the concept of telemedicine to developing countries. The National Centre of Telemedicine is currently involved in a number of international projects. For several years, the Centre has co-operated with north-west Russia to find solutions that will work in a region the size of France, but with a population of 1.5 million inhabitants and extremely difficult infrastructure. The collaboration has led to a number of inquiries about co-operation, advisory services and training from countries in the Third World. The plans of the World Health Organisation (WHO) to make the Norwegian body a "collaborating centre" for telemedicine will lead to even broader international co-operation.

"The whole time, our idea has been to share our knowledge and not have any secrets about our activities. We are willing to take a chance on being good enough to do just that", concludes Pedersen.

National Centre of Telemedicine:

Located at the Regional Hospital in Tromsø (RiTø), the Centre was opened in 1992, six years after the first telemedicine experiments were conducted in Finnmark County. The Norwegian public health authorities have now designated Tromsø as the National Centre of Telemedicine. The most recent national budget allocated MNOK 24 for the Centre's operations and an additional NOK 5 was earmarked for building up an online northern Norwegian health network. All hospitals in the region and a number of physicians' offices are now linked to the common health network, which is structured like an Intranet. The plan is eventually to expand the network to cover the entire country. Through research, development and consultations, the Centre has been established to ensure better health care for everyone through telemedicine. The Department currently has about 50 employees, and there are plans to recruit 30 to 40 more during the current year. About half the staff are technicians or engineers, and the rest consist of physicians, nurses, psychologists social anthropologists, economists, political scientists, sociologists and lawyers. The World Health Organisation (WHO) is discussing designating Tromsø a 'collaborating centre' for telemedicine. The Research Council's Medicine and Health Division and Industry and Energy Division have funded some of the activities at the National Centre of Telemedicine through the programmes "Information technology in medicine and public health services" and the "National Information Network (NIN)".

Telemedicine services:

Distance education: Currently used on a regular basis to provide decentralised training.
Video conferences: Used for meetings where there is a need for visualisation in addition to audio transmissions. Video conferences are used for teaching, diagnoses and treatment.
Teleendoscopy in ENT consultations: Ear-nose-throat (ENT) consultations require a two-way video connection between the primary physician and the specialist. The primary physician uses an endoscope (the instrument used to examine the inside of hollow organs, equipped, in this case, with a video camera) for the examination. One positive side effect of the communication between the primary physician and the specialist is that as he or she gains experience, the primary physician becomes a sort of "semi-specialist" and is able to treat more cases without contracting the specialist.
Teledermatology: Like the ear, nose and throat consultations, it is possible to consult dermatologists about skin diseases by video conferencing.
Teleradiology: Special educations are required to draw correct medical conclusions on the basis of X-rays. Where a radiologist is not available, either the X-ray must be sent or a specialist must be called in. Today, teleradiology is used routinely for transmitting images over a regular offline service. The radiologist's response is recorded instantly by the information system, then made available immediately to the hospital that requisitioned the X-ray.
Telecardiology: Routinely used for ultrasound examinations of the heart (see the article on Vingmed, page xx). The patient is examined at his or her local hospital, which transmits the sonogram of the heart by video conferencing with a specialist at a larger hospital. For many types of heart problems, it is difficult for local hospitals to provide specialist expertise. That being said, many small hospitals have the equipment needed, but it just stands there unused because they have no cardiologist. Guided by a specialist via video conferencing, local physicians can learn to use the equipment on their own.
Telepathology: Frozen specimens are often essential for determining whether a tumour is malignant or benign. Many times, several specialists examine a specimen to confirm a diagnosis. Instead of sending prepared slides by post from one hospital to another to get a second opinion, these consultations can now be handled by video conferencing, with both parties examining images of the frozen specimen at the same time. It is also possible to send pictures of such slides by email.
Teleopthalmology: A project is currently underway to investigate the expediency of remote diagnoses for diabetic retinopathy. If the system proves good enough, the service will become routine.
Telepsychiatry: The National Centre of Telemedicine has been testing the use of telemedicine for psychiatric consultations by video conferencing. Experience indicates that the physical distance which the media creates between patient and psychiatrist is conducive to more openness.
Diabetes: Diabetes-induced leg ulcers can be photographed and the images can be transmitted as ordinary email attachments. A specialist can look at the pictures, pose a diagnosis and give advice about further treatment.

Human rights in the petroleum sector

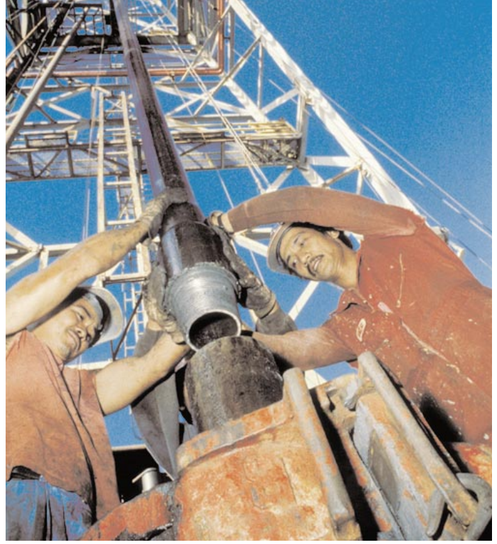
The growing internationalisation of the Norwegian petroleum sector entails new challenges in terms of research on culture, politics and the social sciences, as well as in the economic sphere. One of the imperatives inherent in these international challenges involves the need to link technological and social science research in the petroleum sector. In response, the Research Council of Norway has launched Petropol, a research programme which focuses on the challenges imposed by the internationalisation process. Among other things, the programme will be exploring the demands internationalisation places on the petroleum industry, how companies adapt to change, and the potential economic and political consequences of change.

Petropol represents an effort to enhance researchers' expertise on countries outside Norway and the North Sea region, which could potentially influence Norwegian petroleum activities. Projects under the auspices of the Petropol programme are comparative, and require close contact with leading researchers and research centres abroad. The programme will be showcasing areas such as technology, the impact of geopolitical and cultural factors on the petroleum industry, the organisation of marketing efforts, forms of corporate co-operation, general national and international conditions, and other factors which affect corporate strategies and competitiveness. Additionally, the program has put human rights and democracy building on the agenda in terms of the problems involved in trading with regimes that violate human rights. Thirteen research communities located in Bergen, Stavanger, Trondheim and Oslo, respectively, are participating in the Petropol programme.

"By linking technology research to more and better research on organisational, social and political issues related social science research in the petroleum sector, it may be possible to gain essential new insight and identify better strategies", comments Helge Hveem, chairman of the Programme Committee for the Petropol programme.

http://www.sol.no/forskningsradet/program/profil/ petropol/

Anita K. L. Thorolvsen



CHALLENGE: The internationalisation of Norway's petroleum sector calls for research into its potential economic, political and organisational consequences. (Photo: Ocean Drilling Programme)

A Colourful Constitution Day

A RAINBOW: Different skin colours have increasingly become part of Norway's already-colourful Constitution Day. Will the celebrations survive a multi-cultural society characterised by increasing internationalisation and globalisation?
(Photo: Anne Schanche Kristoffersen)

For nearly 180 years, the 17th of May has been the day on which Norway celebrates itself and its Constitution with marching bands, the Royal family, decorative birch branches, ice cream, soft drinks and parades made up of children of all ages waving colourful Norwegian flags and shouting "Hurrah". Norway's Constitution Day is totally devoid of military symbols. Even otherwise rather reserved Norwegians tend to let down their hair on this day, celebrating with their families and generally enjoying life.

Yet 17th of May celebrations are not all parties and flag-waving. The class struggle, the EU debate and controversial immigration issues are all reflected in the national ritual, challenging and threatening the tradition. While some criticise the celebration for being chauvinistic and ethnocentric, others react to the fact that 17th of May parades are becoming increasingly "colourful".

A group of social scientists at the Diakonhjemmet Hospital and College in Oslo have taken a closer look at this conflict under the auspices of the Research Council project "Ethnic relations and national symbols". The scientists did field work among immigrants in Oslo in 1998 and 1999 to determine whether the Constitution Day celebrations accentuate the exclusively "Norwegian" in a way that excludes Norway's new residents.

"The answer is no. Immigrants generally participate in 17th of May celebrations and view the day as a holiday", comments researcher Ånund Brottveit. "For them, the day commemorates universal values such as independence, democracy, human rights and freedom from oppression. At the same time, they see the day as being very pleasant and fun for children, a day filled with life and vitality. Brottveit believes there are signs of changes in public opinion. Following a bomb threat in the 1980s, immigrants gained a clearly more legitimate place in the ritual. Since then, the Oslo schools have made the immigrant representatives more visible in the children's parades. Last year, Oslo appointed a Pakistani Norwegian woman to head the city's 17th of May Committee. "The celebration of Norway's Constitution Day has become very inclusive, signalling a nationalism that is less ethnic and more democratic", Brottveit concludes. It appears this ritual has a capacity to adapt and change that will allow it to survive in a more globalised world.

Siw Ellen Jakobsen

New stethoscopes talk to computers

The good old stethoscope has seen little change since it became a common tool among physicians nearly 180 years ago. The last stethoscope-related sensation was in the 1950s, when someone discovered the wisdom of placing microphones in the most sophisticated instruments to magnify the sound. Since then, changes have mainly involved improved ergonomics and/or microphone technology.

The Norwegian company Meditron AS now intends to revolutionise the concept of what a stethoscope is by introducing sensor-based, electronic instruments. As a result of inter-disciplinary product development, the company has created an entirely new concept: stethoscopes equipped to listen to, store and analyse body sounds.

In addition to having vastly improved listening qualities compared with old-fashioned stethoscopes, the high-tech variety can be linked to a computer. Sound signals can be visualised, stored and retrieved for later comparisons with new recordings. Doctors can also email sound files to specialists, when so required.

One of the advantages of the new stethoscope systems is that the listening frequencies have been vastly expanded, at the same time as the patented sensor system captures and reproduces sounds more clearly and with less electronic and ambient noise than ordinary stethoscopes. What is more, the system is module based, meaning different elements can be combined to expand the areas of application. For example, there are modules for use with children and modules for mechanical listening devices designed for car mechanics! The stethoscopes can also be used to listen to other sounds, from breathing to blood flow – in humans and animals alike. It is also possible to add a distributor, allowing several scopes to be linked to listen to the same patient.

The company's founder, Birger Orten, was awarded the Inventor's Prize by the Norwegian Industrial and Regional Development Fund in 1995, while Terje Meyer's design won the Norwegian Design Council's Outstanding Design Seal in 1998.

Mona Gravningen Rygh

HIGH TECH: The modern stethoscope transmits sounds to a computer for analysis. (Photo: Meditron)

Can life be hard to digest?

Work-related stress, too much coffee, too little sleep, irregular meals. These factors are everyday realities for many people. Individuals who lead this lifestyle are often bothered by bloating and stomach pain, and sometimes also by aches and pains in other parts of the body.

Some cases of indigestion, or dyspepsia as doctors call it, are so serious that they require medical treatment. For a long time, doctors were uncertain as to whether these pains are really in the heads or stomachs of these patients. Now, psychiatrists and physicians at Haukeland University Hospital in Bergen have discovered that patients who suffer from indigestion often struggle with anxiety and depression as well.

"We believe the pains are part of a viscous circle: When patients struggle with psychological problems, their stomachs hurt, and vice versa. We are the first to prove that these patients have a subnormal level of activity in the vagus nerve. Our theory is that the vagus nerve, a long nerve that runs from the stomach to the head, acts as a link between mental and physical health, meaning it does not make much difference whether patients are treated for their psychological problems or stomach pains, as long as they get treatment", explained Professor Arnold Berstad during a presentation of the research project at an international conference entitled "Clinical Neuroscience and Mental Health". The research project has received funding from the Research Council's "Mental Health" programme over the past few years.

Researchers have determined that both cognitive therapy and muscle relaxants, for example nitroglycerin, bring patients relief. When ulcer bacteria were discovered 12 years ago, those suffering from ulcers got better as soon as the offending bacteria was removed. However, one large group of patients with similar symptoms did not show improvement.

Previously, indigestion was often misdiagnosed as an ulcer. Berstad is afraid that many of these same patients are currently being given other diagnoses which are not correct either. A research project will now be initiated to see whether the stomach pains of patients diagnosed with fibromyalgia might have the same causes as those of indigestion patients.

Berstad is also of the opinion that a large number of ailments diagnosed today as food allergies actually belong to this category. According to the professor, textbook medicine has not taken stomach pains seriously enough, and the result is that food allergies have become a growth industry for alternative medicine.

Haukeland University Hospital: *http://www.haukeland.no/utsiden/english/index.asp*

Siw Ellen Jakobsen

STRESS: According to researchers at Haukeland University Hospital, patients who suffer from indigestion are frequently experiencing problems at home and/or at work. (Photo: Samfoto)

Carbon dioxide stored under the seabed

The Norwegian enterprise Statoil has developed a technique for injecting carbon dioxide (CO_2) produced in conjunction with natural gas production into huge reservoirs beneath the seabed.

"Studies indicate that the emissions become encapsulated in the reservoir and stay there", comments Kristin Bremer Nebben, Statoil's head of information.

Natural gas from the Sleipner fields in the North Sea contains nine per cent of the greenhouse gas CO_2, while customers in Europe want natural gas containing a maximum of 2.5 per cent CO_2. Consequently, most of the CO_2 is extracted and pumped into aquifers in sandstone formations 1000 metres below the seabed.

"While CO_2 is used to enhance oil recovery at other production sites, on the Sleipner fields, it is injected into an empty reservoir. This is the unique aspect", says Nebben.

The Sleipner technique is now the subject of a research project designed to test methods of exploring for and producing oil and gas. It can also be used to trace how CO_2 will disperse through porous sandstone when the pores are filled with saltwater. The project is intended to establish broad consensus between energy companies, research communities and the authorities regarding how CO_2 storage can be planned and monitored safely and efficiently. The goal is to have the technology ready for implementation the day international environmental agreements order for industrial countries to make major cutbacks in their CO_2 emissions.

"We believe that Sleipner has been an inspiration for a number of similar projects currently 'in the pipeline' in Canada, Australia and the USA", says Statoil researcher Olav Kårstad, as his colleague Tore Torp nods his agreement.

IEA GreenhouseGas R&D Programme:
http://www.ieagreen.org.uk/
Statoil: *http://www.statoil.com*

Bjarne Røsjø

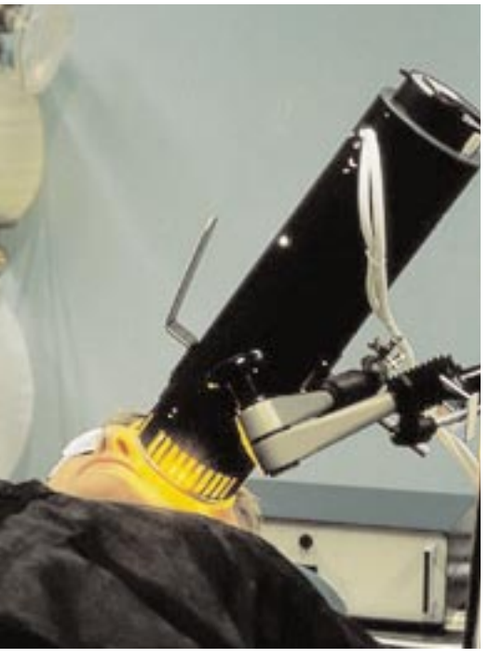
UNIQUE: Statoil has stored two million tonnes of CO_2 under the ocean floor of the North Sea's Sleipner field since October 1996. The project is currently the only one of its kind. (Photo: Statoil)

EU information

The co-operation between the EU and Norway is based on the European Economic Area Agreement, and comprises the EU's 5th Framework Programme for R&D. Norway participates on equal terms with EU member states, and contributes to the budget of the framework programmes.

The Research Council of Norway has a special information centre for EU research: the Norwegian EU R&D Information Centre (EU ForskningsInfo), which can be helpful in providing additional information. The Centre is an associated member of the European Network of Innovation Centres (Associate Innovation Relay Centre).
Internet address:
http://www.forskningsrådet.no/-fag/eu/

The age of enlightenment



ENLIGHTENED: A special lamp is used to illuminate the cancer during treatment. (Photo: Trond Warloe)

A salve is rubbed on the patch of skin affected by cancer, then a special light is directed at the area. The cancer cells become overly sensitive to the light and die, while the healthy cells tolerate the light without any problem. Known as photochemotherapy (PCT) or photodynamic therapy (PDT), the method is based on photosensitising substances which turn toxic in the presence of light.

A group at the Norwegian Cancer Hospital has specialised in the use of a derivative of 5-amino lavulinic acid, ALA, which can be blended into a salve and rubbed directly on a patch of cancerous skin. A few hours later, the area is subjected to light from a halogen bulb.

More than 90 per cent of the patients suffering from basal cell carcinomas, a very common variety of skin cancer, are permanently cured by this treatment. In addition to obtaining excellent cosmetic results, the method has few side effects and is far less expensive than conventional cancer treatments.

Methods are currently being developed for using photochemotherapy to treat carcinomas in the buccal cavity (mouth), respiratory tract, oesophagus, stomach, colon and bladder. Such cures would involve shining the light from inside the patient, which would be facilitated by an endoscope. The beauty of the method is that photochemotherapy can be used to cure cancer without resorting to the removal of all or part of the organ in question.

Researchers at the Norwegian Cancer Hospital are currently co-operating with colleagues in China. In the Henan Province, along the Yellow River, the incidence of oesophogeal cancer is 200 times as high as it is on average in Norway. Under the auspices of a joint research project, the patients selected for photochemotherapy are in an early stage of cancer, meaning there is time to test the treatment. The first follow up showed a cure rate of about 50 per cent, and scientists expect that about half those not cured after the first treatment will respond to a second treatment, which translates into a success rate of at least 75 per cent. However, the patients will have to be followed up for quite some time since there is a strong chance of relapse.

While clinicians are testing how to optimise the treatment itself, another group is continuing to pursue pioneering basic research first started in the 1970s. They are now working on derivatives of ALA which are so promising that a separate company, PhotoCure, has been set up to handle the business aspects of the patent applications currently pending in more than 30 countries. A group of investors is now involved in the company, along with the Norwegian Industrial and Regional Development Fund and the Research Council of Norway.

Mona Gravningen Rygh

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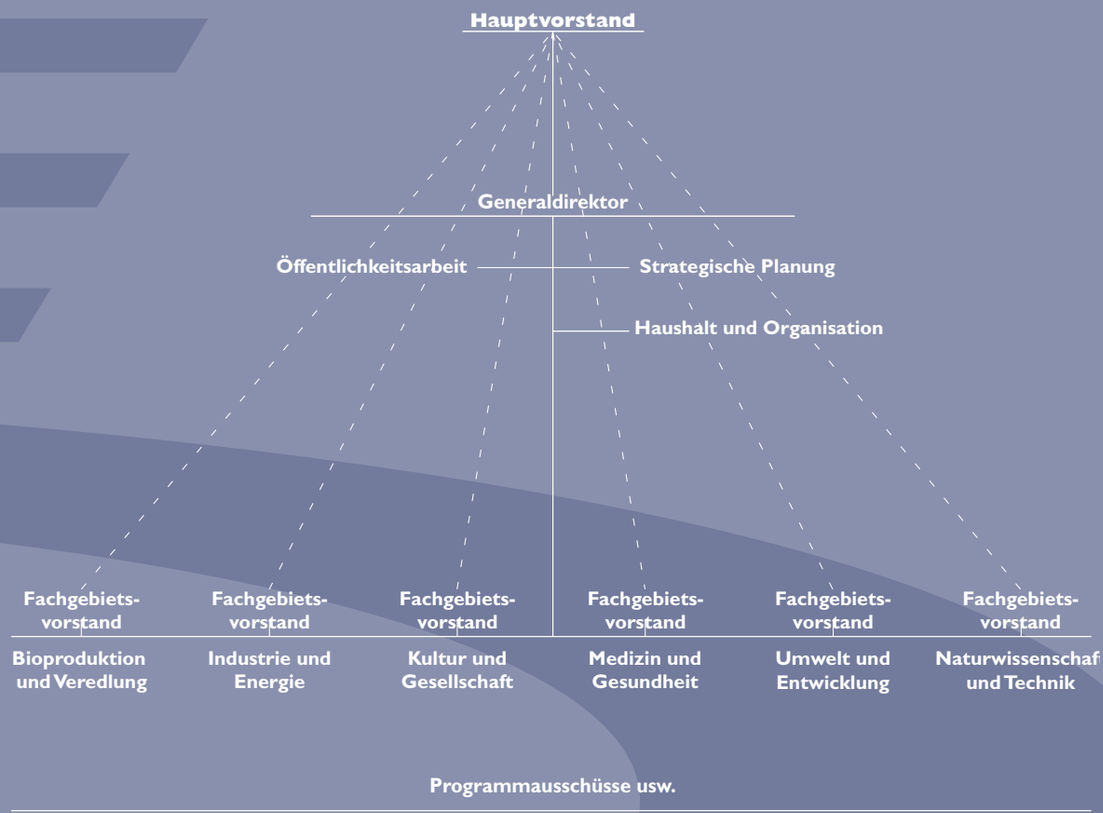

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New anti-bacterial substance from the sea

Norwegian scientists recently discovered an enzyme in the Iceland scallop. *Chlamys islandica,* which kills bacteria in human beings and fish. The substance is now being produced in such large quantities that commercialisation is a distinct possibility.

BY SIW ELLEN JAKOBSEN

GOURMET: The muscle in the Iceland scallop, Chlamys islandica, has long been a gourmet favourite, and now researchers have discovered a substance in the mollusc that may be able to prevent or cure diseases in humans. (Photo: Frank Gregersen, Fiskeriforskning)

Decades of antibiotic use have led to new strains of infectious bacteria which are resistant to drugs. Over the past few years, several different groups of researchers have found that marine organisms may be a source of a variety of potential new pharmaceutical compounds. Researchers at the Norwegian Institute of Fisheries and Aquaculture Ltd. (Fiskeriforskning) in Tromsø have discovered a substance in Iceland scallops – chlamysin – that appears to have an anti-bacterial effect on disease-producing bacteria in humans and animals. The scientists now know the gene that codes the production of this substance, meaning it is possible to reproduce it recombinantly, that is, in yeast cells. The substance occurs in Iceland scallops in such small amounts that it would have been neither practical nor financially feasible to extract it from scallops alone, but now it is possible to manufacture such large quantities of the enzyme that commercialisation is a distinct possibility.

Until recently, this research was shrouded in considerable mystery, but now that the patent is pending, scientists are free to talk about the properties of the substance. Their results were published in *FEBS Letters,* the journal of the Federation of European Biochemical Societies this past December.

UNIQUE

"The enzyme we've discovered is entirely unique in a scientific context", observes Bjørnar Myrnes, the researcher in charge of the Institute's work with marine enzymes in cold-water habitats. "We found the substance in the crystalline style, an organ found only in the digestive gland of molluscs. It appears that the enzyme plays a dual role in the mollusc, being involved in both the disease defence system and the digestion of bacteria".

Myrnes explains that the structure of chlamysin is similar to lysozym, an enzyme derived from a scallop found off the coast of Japan. There is a great deal of lysozym in spit and tears. In fact, it is this enzyme that keeps bacteria at bay in these body fluids. Although lysozym and chlamysin have similarities, they work differently.

To date, researchers have discovered four different anti-microbial substances in the Iceland scallop. However, chlamysin is the only substance shown thus far to have an effect on disease-producing bacteria, including *Listeria* which causes disease in human beings.

MARINE POTENTIAL

For quite some time, scientists have speculated that Arctic marine organisms must possess some very special qualities to survive in the cold waters of the north. They live at constant low temperatures, ranging from -1° C. to +4° C. The organisms' enzyme activity levels are actually high at low temperatures, and they rarely tolerate much heat. However, chlamysin is an exception to that rule.

"Thirty days at room temperature or being heated to 70° C. for 15 minutes does not lower the enzyme activity level. Now that is unique", explains Myrnes. "The discovery of this enzyme is indicative of the tremendous potential inherent in Arctic organisms. Norway has focused almost exclusively on oil for a long time, but now we have to begin taking a closer look at our other marine resources. They represent undreamed-of possibilities."