The Magazine from Carl Zeiss

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Innovation

11

- Climate Change, Glaciers and the Iceman
- Processes of Cell Division
- All Eyes on Zeiss Lenses

Contents

Things that Change the World

macroscopically

Are the changes established in the past 100 years constantly recurring, natural fluctuations in the climate, or are they really irreversible climate changes influenced by mankind? The experts do not totally agree on this issue. What would appear to be certain is that our way of life, and the continuing and strongly expanding industrialization in particular, is making a (negative) contribution to the fluctuations and changes evident in our climate. The articles "Climate and Glaciers", "Ötzi the Iceman" and "Hot on the Trail of Climate Changes" provide answers, opinions, and insights into this subject, highlighting issues connected with the change in the earth's climate currently discernible. In Germany the Federal Education and Research Department has declared 2002 as the Year of the Geosciences under the motto planeterde® (Planet Earth). Many events and activities on the topics System Earth, Air, Fire and Water are taking place this year at various locations in Germany.

Fig 1: Aerial photograph of the Rocky Mountains in North America

microscopically

As far back as 1855, *Rudolf Virchow's* statement "omnis cellulae e cellula" – all cells stem from one cell – laid the foundation stone for the science of cell biology and culminates in the sentence that the development of the organic world constitutes an unbroken chain of cell divisions. The 2001 Nobel Prize for Medicine was awarded to *Paul Nurse, Timothy Hunt* and *Leland Hartwell* for their discoveries and descriptions of components and processes in the individual cell at what is known as the cellular level – processes which very decisively regulate and influence our lives. Fundamental molecular mechanisms control every cell division process. This process has remained unchanged during all the exciting events that have punctuated the evolution of life on earth over millions of years. In principle, the cell division process is virtually identical in yeast cells, plants, animals and humans. The articles "Images of Cell Division", "Pioneering Discoveries About the Cell Cycle" and "All-round Chromosome Analysis" provide an insight intro these processes.

Fig 2: Stages of development of C. elegans (DIC contrasting)

globally

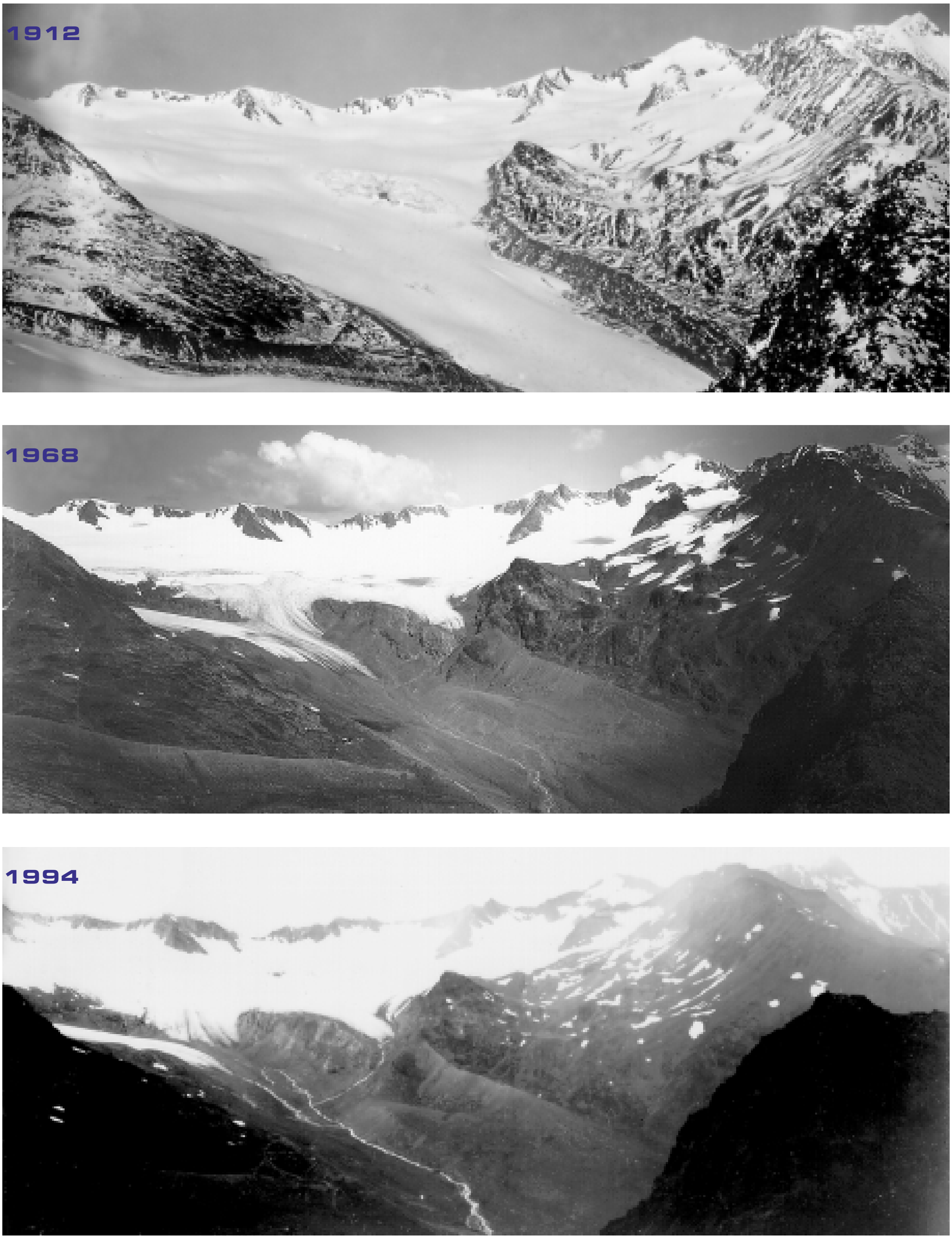
Macroscopically and microscopically, climate changes and cell division are global processes and events on Planet Earth which we, as human beings, follow and analyze. Influence must and can only be exerted with caution and should lead solely to an enhancement in the quality of life enjoyed by all living creatures. Since its founding, the company Carl Zeiss has always played a key role in the field of research and development by creating products for analysis, measurement, observation, recording, communication and information, making its own contribution to ongoing knowledge enrichment and to a lasting improvement in the general quality of life.

June 2002

Dr. Dieter Brocksch

The Global Climate Change: A Challenge to

Wolfgang Seiler



The Vernagt Ferner in the European Tyrol region. The photographic documentation from the years 1912, 1968 and 1994 clearly shows the dramatic shrinking of the glacier surfaces which is occurring in the entire Alpine region – and not only there! – due to climate changes (reproduced with the kind permission of the Bavarian Academy of Sciences in Munich, Commission for Glaciology).

Society and Science

At first glance, the temperature increase would appear to be relatively insignificant. However, when we consider that the temperature difference between the Ice Age and the interglacial period was only 4 to 5 °C, the increase suddenly appears in a totally different light.

In the past 20 to 40 years the global temperature rise has accelerated, leading to new temperature records form one year to the next. Since the beginning of the temperature measurements, the annual global temperature measured in 2001 was exceeded once only – during the El Niño scenario in 1998. The greatest increases occurred over the continental regions of the northern hemisphere, particularly in latitudes north of 30 °N.

The shrinking of the glaciers, the thawing of permafrost at increasingly greater depths and the reduction in the area of the Arctic covered by sea ice all testify to the climate change currently underway. The best evidence for global warming is the temperature of the layer of air close to the ground which has increased by approx. 0.7 °C since the beginning of industrialization about 140 years ago.

The causes

What processes are responsible for this climate change, and to what extent, is impossible to say with absolute certainty. A single cause is not to be expected due to the large number of parameters that determine the climate. Current knowledge would suggest that about 60 % of the climate change is attributable to such human activities as altered land use, deforestation, agricultural and industrial activities, and increasing energy consumption. These processes are responsible for the increase in emissions documented in the past 100 years and ultimately for the rise in concentrations of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorohydrocarbons (CFCs) in the atmosphere. These trace gases absorb the thermal radiation emitted by the earth's surface and use it to heat the layers of air close to the ground. By analogy, this is often known as the "greenhouse effect" and the associated trace gases as "greenhouse gases". If the atmosphere did not contain these greenhouse gases, a mean temperature of –18 °C would hypothetically result, i.e. 33 °C below today's value. Therefore, any change in the concentration of these greenhouse gases must inevitably lead to a climate change.

Climate of the future

Since industrialization, the concentrations of the most important greenhouse gases CO_2, CH_4 and N_2O have increased exponentially to levels far exceeding the concentrations detected in the past 450,000 years. About half of the increase in CO_2 concentrations has occurred in the past 30 years. If we generally assume that the surface temperature reacts to these concentration changes with a delay of approx. 30 years, we can conclude that about only one half of the climate change caused by mankind has in fact taken effect. Therefore, according to current knowledge, further warming must be expected with a high degree of probability.

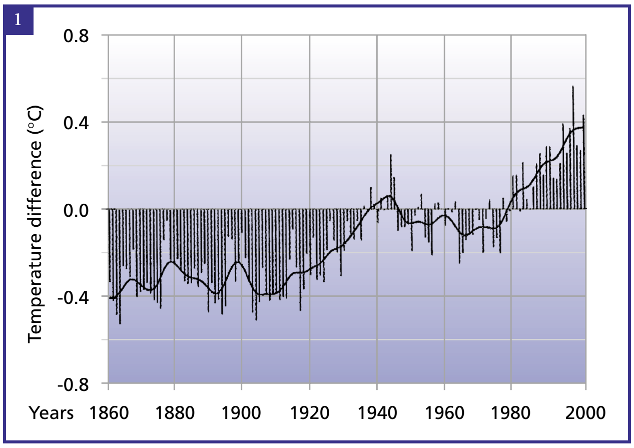
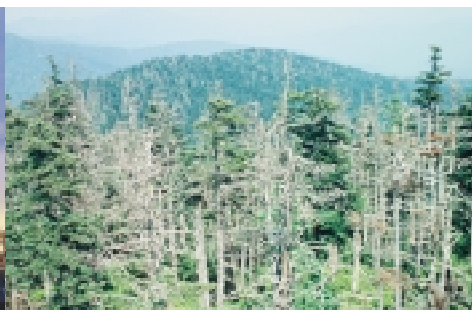


Fig. 1: Deviation in global temperatures in the layer of air close to the ground relative to the mean value for the period 1961-1990 (Source: Hadley Center)

The CO_2 and N_2O molecules emitted by mankind remain up to 120 years in the atmosphere until they are degraded by biological, chemical and physical processes. This means that the increase in CO_2 and N_2O concentrations in the atmosphere occurred after the increase in the emission of these gases. As a result, the concentrations of these gases will continue to rise, even if the emissions of CO_2 and N_2O attributable to mankind are successfully frozen at the current level. What is needed is an immediate reduction of the emissions by up to 80 %. In future, CO_2 concentrations will continue to rise due to the increasing consumption of natural fossil fuels such as coal, natural gas and mineral oil. The International Energy Agency (IEA) assumes that CO_2 emissions will increase by about 50 % by the year 2020 – from today's 26 bil-

lion tons to around 38 billion tons. Depending on social and economic developments during the next 100 years, current scenarios suggest that the annual CO_2 emission anticipated in 2100 will even out at between 18 and 110 billion tons. In addition, a rise in CH_4 and N_2O emissions must also be expected, accompanied by an increase in the world population and the associated intensification of agriculture.

> *"We can believe in the future and work to achieve it and preserve it, or we can whirl blindly on, behaving as if one day there will be no children to inherit our legacy. The choice is ours; the earth is in the balance."*
>
> *Al Gore, "Earth in the Balance – Ecology and Human Spirit" Houghton Mifflin Company, 1992*

The repercussions

All global climate models predict a further increase in temperature which is estimated at values between 2 and 6 °C by the end of this century. The fluctuation margin is attributable, firstly, to the different emission scenarios used as a basis for the forecasts. Secondly, there are still considerable gaps in our current knowledge about the complex behavior of our climate and about the diverse feedback mechanisms, e.g. with the biosphere. This knowledge can be expanded by interdisciplinary research projects if the reliability of the global and regional climate models is to be improved. This constitutes an important scientific challenge and will occupy scientists for many years to come.

Even if the temperature increase is successfully limited to the lower value of the current temperature forecast, a climate status will be achieved which occurred at only a few times during the past 2 – 3 million year history of our climate. The climate change is associated with many different effects which vary considerably from one region to another and will hence have different impacts on the various countries of the world. Some countries will benefit from a climate change, while others will be all the more adversely affected.

A rise in sea level by about 50 cm may be the result by the end of this century. Lowlying islands and coastal zones, cities lying directly in coastal areas and large, fertile river deltas with dense populations will be endangered by flooding. The expected change in atmospheric circulation will lead to a change in the temporal and spatial distribution of rainfall, with direct consequences for agriculture and forestry. The provision of sufficient and clean drinking water will be jeopardized in many parts of the earth. The semi-arid countries, which are already suffering considerable climatic stress today, will be particularly severely hit. These include in particular the developing and newly industrializing countries in the tropics and subtropics which number among the regions with the highest population growth rates. In these countries the link between climate change and population growth will further aggravate the existing social conflict and destabilize society. Due to the increasing networking of international economic interests, the industrialized countries will also be affected by the consequences of the climate change suffered by the developing and newly industrializing countries.

An important consequence of the global climate change which has not been given adequate attention is the increased incidence of extreme meteorological events associated with flooding, drought, storms, avalanches, etc. Such consequences of the climate change will most definitely have considerable ecological and socio-ecological repercussions which can barely be assessed as yet. A good indication of what awaits future generations is the statistics published by global insurance companies which show an extreme increase in the number of weather-related claims and damages – a sum which is comparable to the financial outlay required for successful climate protection.

Protective measures

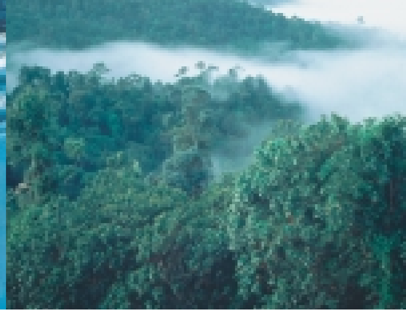
Climate protection must therefore not only be focused on measures aimed at reducing the emission of relevant trace substances, but must also contain measures which provide protection against the repercussions of the global climate change.

In view of the expected impact of the climate change, the rapid implementation of measures to reduce greenhouse gas emission is required, even allowing for various uncertainties. As CH_4 and N_2O emissions are primarily caused by agricultural activities which cannot be significantly reduced due to the increase in the world population to approx. 3 billion by 2050, the climate protection measures will concentrate on CO_2.

To reduce the human-related temperature rise to a value of 1 °C, the global CO_2 emission recorded in 1990 must be decreased by at least 50 % by the end of the this century. With a 25 % share of the world population, the industrialized nations currently account for 75 % of global CO_2 emission. Taking into account the long atmospheric dwell time of anthropogenic CO_2, this relationship looks even more unfavorable for the industrialized nations. Consequently, a reduction in CO_2 emission of 80 % is demanded of the industrial nations before the end of the century.

The dilemma is that the countries contributing most to the climate change are least affected by its impact and are not therefore subjected to any direct pressure to implement suitable measures for climate protection. The Third World countries suf-






fering most from the climate change can contribute least to climate protection. This obliges the industrialized countries to counteract further climate change by undertaking the appropriate preventive action out of a sense of responsibility toward future generations.

An up to 80 % reduction in CO_2 emission is not some utopian dream. Technologies for the reduction of energy consumption and for CO_2-free energy production already exist today. These possibilities include efficient energy utilization, the use of new CO_2-free technologies, the increased utilization of regenerative energy sources and combined heat and power generation.

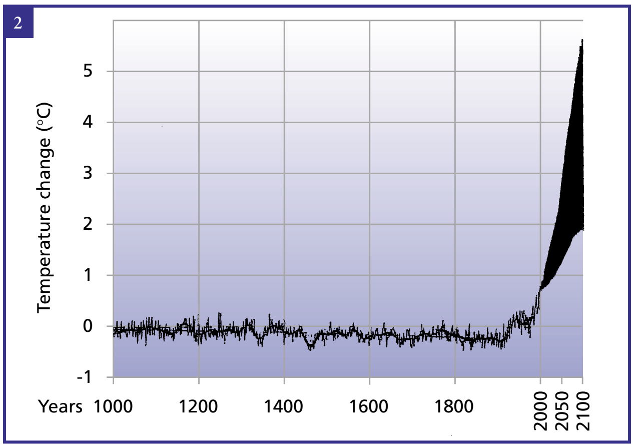
One thing is sure, however: a general panacea to remedy all problems at one stroke and without the personal commitment of each individual simply does not exist, and will not exist in the future either. Measures which have been skilfully matched to each other and adapted to regional conditions are needed. They must be constantly monitored with regard to their cost efficiency, technological development and social acceptance, and if they pass the test, they must then be implemented consistently and systematically.

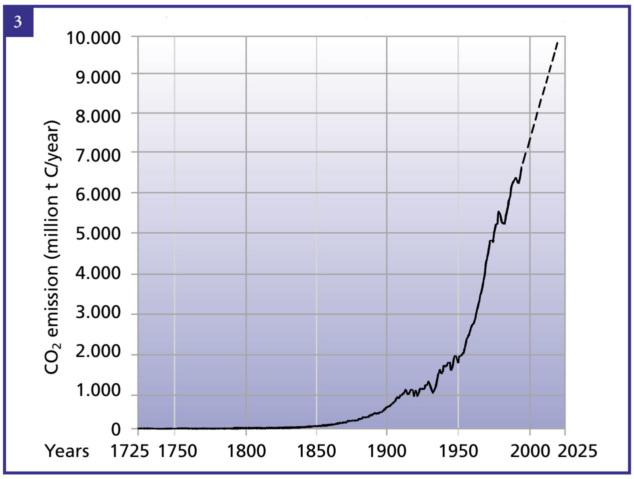
The factors determining climate change are a challenge not only to science but also to society. A significant reduction in CO_2 emission can only be achieved by creating the right marginal conditions and by providing major incentives to encourage greater awareness in the handling of energy. These include the structuring of energy prices and financial support in the development and market launch of new CO_2-free technologies such as the thermal insulation of houses and the increased use of regenerative energies (wind, water, sun, biomass).

The negotiations about the Kyoto Protocol indicate that the implementation of the currently existing possibilities for a significant reduction in CO_2 emission will be no mean feat. The provisions decided in Marrakech, where allowance was made for natural CO_2 sinks, are a compromise. The original goal of an approx. 5 % reduction in CO_2 emission by the industrialized countries by 2012 will not be met. The discussion about climate protection initiated at the highest government level by the "Kyoto Process" points in the right direction and justifies the hope that the aspired goal of stabilizing the temperature rise at a "tolerable value" will be achieved in future protocols on the reduction of greenhouse gas emissions still to be negotiated.

Fig. 2:
Forecast temperature rise for the period 2000 – 2010 relative to the temperature variation of the past 1000 years (Source: IPC 2002).

Fig. 3:
Co_2 emission through the use of fossil fuels such as coal, natural gas and mineral oil (IEA forecast 2002).





Prof. Dr. Wolfgang Seiler, Karlsruhe Research Center, Institute of Meteorology and Climate Research (IMK-IFU), Garmisch-Partenkirchen, Germany

Ötzi the Iceman

Manfred Schindler

The global climate is warming – a process which, though scarcely felt, is nevertheless clearly visible. Glaciers have been receding for years, and not only in the polar zones, in the high mountainous regions of Central Asia or in the northern and southern areas of America! Even in the European Alps, experienced hikers are baffled to see a trail which ran above the edge of a glacier as recently as the previous year now passing through rock and rubble. The increasing melting of snow and ice masses has presented the archeological community with a sensational find and an outstanding research object. A museum has been set up in Bolzano in South Tyrol to house this discovery.

In September 1991, a couple from Nuremberg climbing down from the Finailspitze peak in the Ötztal Alps spotted a human corpse half protruding from ice and melt water residues in a rock trough not far from the marked trail. They informed the landlord of the Similaun lodge who reported the discovery to the Italian police in Schnals and their Austrian counterparts in Sölden, as the site of the find on the edge of the Niederjoch glacier was obviously located on the frontier line between Italy and Austria.

The very next day, an Austrian rescue team arrived by helicopter on the site located at an altitude of 3120 meters. Due to the onset of bad weather, however, they had to return empty-handed to the valley. Among the first reaching the site on foot were the two South Tyrolean mountaineers *Reinhold Messner* and *Hans Kammerlander*. They subjected the corpse and its surroundings to closer scrutiny, and found remnants of clothes and various utensils, including a bow, suggesting that the dead man could hardly be a 20^{th} century victim of a mountaineering accident.

This guess was confirmed a few days later. The body and the collected pieces of equipment had been brought to the Department of Forensic Medicine of Innsbruck University, where *Prof. Dr. Konrad Spindler* of the Institute of Pre- and Early History was consulted. He dated the find to be early Bronze Age – a sensation which hit the headlines worldwide.

The mummy was then transferred to the Institute of Anatomy where it was preserved in a cold storage room at minus temperatures and with a humidity similar to glacier conditions. All articles found on the site were transferred to the Central Roman-Germanic Museum in Mainz, Germany for preservative treatment.

Just who does the Iceman belong to?

In the very first media reports, it was partly assumed that the site of the find was not located in Austria but on Italian territory. It was therefore up to the Italian authorities to decide what should happen to this discovery that was causing such a worldwide sensation. Although the doubts about the nationality of the location appeared somewhat bizarre at first, different views on the exact course of the frontier line were indeed justified, i.e. on whether it runs north or south of Ötzi's icy grave.

When Tyrol was divided after World War I, the victorious Allied Powers fixed the frontier between Italy and Austria on the watershed between the river valleys of Adige and Inn. But what if nature ignores the decisions of politicians, if melting glaciers change the topographic conditions and water channels?

People in South and North Tyrol have continued to use the bridle paths linking the areas from time immemorial, and have driven their flocks to pastures which have been officially documented for centuries, on both sides of the main Alpine crest. Until the discovery of Ötzi, no one had been particularly interested in where to the exact meter the frontier ran through eternal ice and uncultivatable land according to the delimitation of 1919 under international law. However, the increasingly heated discussion about the location's nationality finally necessitated the re-measurement of the national border. As it turned out, the inconspicuous rock trough housing the glacier mummy for thousands of years is in fact located on Italian territory, exactly 92.56 meters from the border line. In other words, the province of South Tyrol was the rightful owner of the find.

Fig. 1:
The site of the find at an altitude of 3120 m above MSL, between Schnalstal (Italy) and Ötztal (Austria). In this area, three passages and cattle drive trails known from time immemorial lead across the main Alpine crest via Niederjoch and Hauslabjoch.

The South Tyrol Museum of Archeology

Was the Iceman a South Tyrolean? Where did he come from and where was he bound? These and many other, hitherto unanswered questions will keep the international scientific community busy for many years to come. Since 1998, the specially built South Tyrol Museum of Archeology in Bolzano has provided this spectacular discovery with a home befitting its importance. Here, the Iceman is stored – without any danger of aging – in a specially designed cold storage complex. The complex comprises a decontamination room, an examination room equipped with Zeiss technology, and two cold chambers with independent refrigeration systems. In one of the chambers, the Iceman is stored at −6 °C and a humidity of nearly 100 % , surrounded by mysterious cold light from which all ultraviolet and infrared beams have been filtered. Visitors to the museum can view the mummy through a window. The preservation principle involving an innovative sheathed thermosystem for the exchange of humidity, without any formation of ice on the mummy's body, has been specially developed and is currently unique in the world.

Fig. 2:
On the upper floor of the museum, a small window allows a glimpse of the preserved glacier mummy inside the cold chamber.

Reconstruction of the Iceman, his clothing and equipment

700 axial sectional images obtained by computer tomography were used to create a stereolithographed 3D representation of the skeleton system and a model of the skull with a level of precision totaling mere fractions of a millimeter. This formed the basis for the reconstruction of the Iceman's body, facial features, hairstyle and beard.
Under a grass cloak, he wore a knee-length upper garment made of strips of goat skin to keep him warm. The "underwear" consisted of a loin cloth made of goat hide which was drawn between the legs. The thighs and lower legs were covered by a kind of leggings also made of goat hide, to which deerskin shoes with soles of bear skin and with a hay lining were attached.
The Iceman´s equipment included a copper axe, a bow made of yew wood, a leather quiver containing some unfinished arrow shafts made of viburnum branches and some arrows with flint heads ready for shooting as well as a dagger with a flint blade.
Two birch bark containers which the Iceman carried with him were not only used for storing food, but also contained embers for a fire embedded in fresh leaves, as can be deduced from charcoal particles found inside.

Figs 3 to 5:
"Ötzi" in the examination room of the cold storage complex at the South Tyrol Museum of Archeology.

The equipment including a Zeiss **OPMI® 111** surgical microscope, a **MediLive 3** CDD camera, an **AxioCam®** digital microscope camera and the associated **KS 300** software is primarily used for constant monitoring of all major preservation parameters:
- the mummy's moisture content,
- its subjective surface condition,
- its weight,
- the color characteristics of its skin,
- its microbiological integrity

The processes performed for this purpose involve the photographic documentation of details of the mummy, examinations of its surface at different magnifications, and spectrometric measurements of the light reflected by the skin at defined measuring points.

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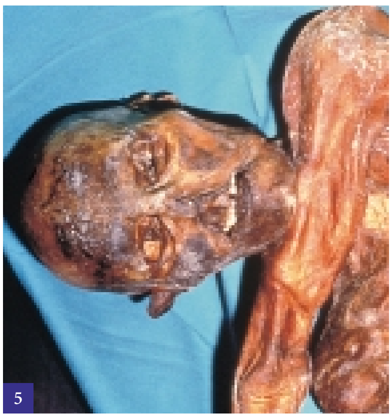
The Iceman, his clothes and equipment form the core of museum's exhibition. A tour through the exhibition area, which has been slightly darkened for reasons of preservation, along special climatized showcases with the original remnants of the items found on site, their excellent reconstructions and very instructive presentations of information in word and picture is a fascinating experience. Interested visitors learn, for example, that scientific studies have estimated the glacier mummy to be approx. 5300 years old, that the Iceman's height at the time of his death was 1.60 meters, that he weighed roughly 50 kg and had probably reached the age of 46 years.

What is so special about this find?

"This find is so unique because organic parts of the clothing and equipment of prehistoric men have never been found before in such an excellent state of preservation and in such completeness. The Iceman was snatched from life for reasons unknown to us, and remained preserved in the ice in this accidental situation, together with his equipment.

In archeological excavations, selected objects are usually found which have been intentionally placed in the location as part of religious or burial ceremonies. The Iceman find, on the other hand, provides a realistic snapshot of man's everyday life in high mountainous regions 5000 years ago.

But not only research into Alpine prehistory is gaining new insights from the Iceman. Other scientific and technical disciplines are also participating in the thorough investigation of the find: medicine (anatomy, radiology, pathology, hematology, dermatology, parasitology, etc.), microbiology, anthropology, paleobotany, cryotechnology" (quote from the museum documentation).



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International research

Angelika Fleckinger, coordinator at the South Tyrol Museum of Archeology, writes that the body itself was subjected to no less than 570 scientific examinations between its discovery and the transfer of the mummy from Innsbruck to Bolzano. 100 samples have been taken, the largest of them weighing 60 milligrams and the weight of all samples together totaling just over one gram. Renowned research institutes from all over the world participated in the studies.

The Osteological Research Laboratory of Stockholm University and the Institute of Anatomy of Innsbruck University, for example, examined the bone structure for age-related degeneration symptoms, and concurrently estimated the Iceman's age to be at least 40 and no more than 53 years at the time of death.

Tissue fibers and bone particles were evaluated for ^{14}C dating by the Research Laboratory for Archeology and the History of Art in Oxford and at the Institute of Medium Energy Physics at Zurich Technical University (Eidgenössische Technische Hochschule). Likewise, botanical fiber fragments from the clothes were analyzed at the Svedborg Laboratoriet of Uppsala University and at the Center for Weak Radioactive Substances (Centre de Faibles Radioactivités) in Paris. The results concurrently showed that "Ötzi" lived in the period between 3350 and 3100 BC.

The list of spectacular research projects could be continued indefinitely. The universities of Ferrara, Camerino, Rome and Bolzano, the Eidgenössische Technische Hochschule in Zürich and the Department of Anthropology and Biology of London University College are currently performing dedicated DNA analyses which, though based on different approaches, are all aimed at gaining further insights into the Iceman's origin and migration.

"Ötzi" is an international project. Over one hundred experts have been involved until now in deciphering the "Homo Tyrolensis" or "Homo Hauslabiensis" as the Iceman has come to be called in scientific terms. We already know a lot about him. For example, he was afflicted by arthritis and suffered from the effects of several fractured ribs, some of his wisdom teeth were missing, the provisions for his journey over the Hauslabjoch consisted of wheat bran, plums and dried capricorn meat, he was protected by surprisingly practical clothing, and he possessed a nearly perfect survival kit.

New discoveries

Initially it was assumed that the Iceman's death had been due to a sudden onset of bad weather leading to hypothermia and exhaustion. In summer 2001, however, *Eduard Egarter*, pathologist and coordinator of the Ötzi research project, and *Paul Gostner*, radiologist at Bolzano hospital, discovered an arrowhead in the mummy's chest and a shot hole under its left shoulder blade. This indicates that Ötzi was shot from behind. A closer analysis of the strangely distorted position of the right hand has now shown that the Iceman also had a deep gash between his thumb and index finger, but that he was nevertheless holding his dagger with the flint blade firmly clenched.

Forensic specialist *Eduard Egarter* thinks that the severity of the hand injury contradicts any assumption that it might have been caused accidentally, e. g. during the carving of the unfinished arrow shafts found in the mummy's quiver. Instead, it can be assumed that "Ötzi" raised his hand to protect himself in the fight and sustained a further injury.

In all likelihood, the arrowhead under the left shoulder blade paralyzed his arm muscles and led to an internal hemorrhage. Weakened and unable to defend himself and to continue his arduous journey, the injured man very probably succumbed to exhaustion and his injuries, primarily the internal hemorrhage caused by the arrow shot. Whether he died within a short time or after hours cannot be said with definite certainty after 5000 years.

Was the Iceman on the run? And if so, why and from whom? Research will continue, as every new insight not only provides answers but also raises new questions at the same time. Many facts will still be brought to light, but a great deal will remain a mystery. – Let us wait and see what the most exciting find of our time is yet to reveal.


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Fig. 6:
On a surface area of 1200 square meters, the South Tyrol Museum of Archeology in Bolzano's Via Museo /Museumsstrasse documents the pre- and early history of South Tyrol from the end of the Ice Age (15,000 BC) up to the Charlemagne period (around 800 AD). The central exhibit is the Iceman and the associated finds.

Further information on:
"Ötzi the Iceman"
www.iceman.it

Sources/photos:
see Masthead

Hot on the Trail of Climate Changes

Claudia Hillinger

In the 20th century biochemistry emerged as a new scientific discipline. It investigates and researches into global element cycles and the biological, physical and chemical processes involved in them.

Carbon, oxygen, hydrogen and nitrogen – these four elements which are so essential for life on earth are subject to a constant cycle. In various chemical compounds they pass through the metabolism of flora, fauna and micro-organisms, are released and are then transported and distributed via the atmosphere and hydrosphere. The organisms in which these processes originate are linked at the level of an ecosystem or a landscape through interactions on a continental or global scale. These processes are controlled by the biology of the participating organisms and by chemophysical cycles in the atmosphere and geosphere. In addition, planetary processes, e. g. the change in the earth's orbit around the sun, fluctuations in incident solar radiation which led to the well-known Ice Ages and, to an increasing extent, anthropogenic interventions – such as the use of fossil fuels or activities in the fields of agriculture or forestry – modify natural biogeochemical cycles.

Can we influence the climate?

Meteorologists have discovered that today's mean global temperature is roughly 0.75 °C higher than in the 19th century. Through industrial production, intensive agriculture and the pollutant emission of motorized vehicles, humankind is throwing the natural carbon cycle in particular off balance. On the one hand, large quantities of carbon dioxide (CO_2) are produced by the combustion of oil, gas and coal while, on the other, forest covering an area measuring more than the equivalent of 40 soccer pitches is being felled every minute across the globe. Through changed land use and the combustion of fossil fuels, about 7.1 billion tons of carbon are emitted every year. Global measurements show that approximately 3.2 billion tons of this "end up" in the atmosphere (Fig. 1). The decrease in global forest cover is also reducing the photosynthesis potential at the same time, i. e. there are fewer plants to convert the carbon dioxide into plant carbon compounds through photosynthesis and emit oxygen in the process. As a result, the concentration of CO_2 in the troposphere has risen from approx. 280 ppm (parts per million) to about 370 ppm in 1999 since the beginning of industrialization. Like the glass walls of a greenhouse, this prevents the emission of the solar energy incident on the earth as thermal radiation into space. Global warming is the result. In addition to CO_2, which accounts for the major portion with a figure of 60 %, methane, halogenated hydrocarbons and nitrogen dioxide also contribute to this anthropogenic greenhouse effect. Calculations of climatologists show that the mean temperature of the earth's atmosphere could rise by about 2.5 °C by the year 2050. Warnings are increasingly being voiced that this could lead to melting of the polar ice caps, in a rise in sea level and in such dramatic incidents as flooding and severe storms with the devastation of large areas of land.

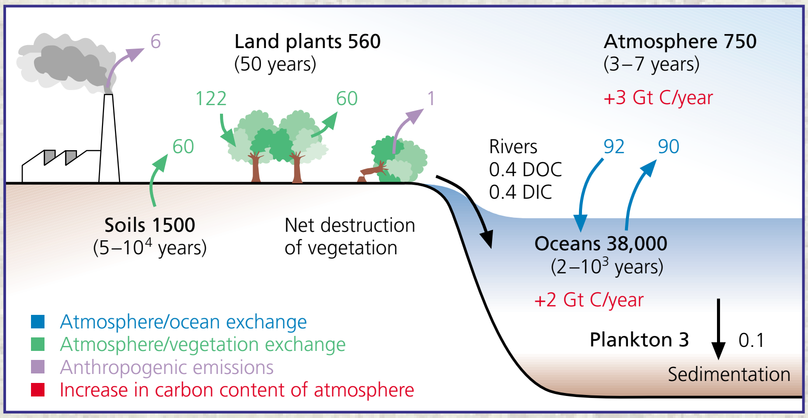

Fig. 1:
The global carbon cycle
(*after Schlesinger*, 1997)
– bold: quantities stored in Gt C = 10^{15} g C
– in parentheses: mean dwell time
– rivers Gt C/year

DOC: dissolved organic carbon
DIC: dissolved inorganic carbon

Forests as climate watchdogs

Politicians from all over the world began negotiations on a Framework Convention on Climate Change aimed at regulating global emissions of greenhouse gases. In an initial result, the 1997 Kyoto Protocol, Europe undertook to reduce its emissions of carbon dioxide by at least 8 % over the volume recorded in 1990 in the period from 2008 to 2012. The Kyoto Protocol makes allowance for the creation of new CO_2 sinks in addition to a reduction of CO_2 emissions. Forests, for example, absorb approximately one third of carbon emissions across the globe. What exactly are recognized as official biological "carbon sinks" in the implementation of the Kyoto Protocol gave rise to heated discussions between scientists and politicians. The signatory states did not legally commit themselves to documenting measures for the fulfillment of the Kyoto Protocol transparently, comprehensibly and verifiably until the UN climate talks held in Marrakech in November 2001. To be able to quantify the carbon balance of the biosphere from the local to the continental level, however, global measurements are required.

Test lab above the treetops

Together with international research teams, the Max Planck Institute for Biogeochemistry in Jena analyzes various aspects of the carbon cycle. The 130 employees of the institute, including biologists, meteorologists, physicists, geoscientists and mathematicians, examine such questions as: "Where do the global sources and sinks of carbon lie? How are processes regulated in ecosystems? What repercussions do changed climatic conditions have on the global element cycles?"

To clarify these questions, the Jena scientists are more reliant on outdoor investigations than researchers in other disciplines. They operate measuring stations all over the world, including Russia. An over 28-meter-high measuring tower (Fig. 2), for example, allows the scientists to measure the difference between the CO_2 absorbed and emitted by the forest in order to answer the much-discussed question as to whether a forest with an old tree population constitutes a natural CO_2 sink. To determine the net CO_2 flow between the vegetation and the atmosphere, the Jena researchers have mounted several instruments on their measuring tower. These permit them to measure fluctuations in the CO_2 concentration of the air passing the top of the tower 20 times a second. Ground-based measuring stations (Fig. 3) are also operated at the same time. Here, the Jena scientists wish to establish to what extent forest soils represent a carbon sink. The air, wood, humus and plant samples collected are analyzed in the institute's central labs, e. g. by using dendrochronological examination methods or ratio mass spectroscopy. Annual ring counts (Fig. 4), for instance, do not only provide information on the age of the trees examined. The rings also allow conclusions to be drawn about climate fluctuations during the tree's life. In years of dryness they are narrow, and in years with more rainfall they are wider. Such signatures allow a precise reconstruction of climatic incidents. Isotopic ratio analysis indicates how a plant processes the CO_2 it has extracted from the air. For this purpose, the researchers make use of the fact that carbon in nature does not only occur with the atomic mass of 12, but also with the masses 13 and 14 in tiny, but known quantities. Chemically, the CO_2 molecules with different weights of the various isotopes behave identically, but their physical properties and their reaction speeds are different. This means that plants process $^{12}CO_2$ from the air more quickly than $^{13}CO_2$ or $^{14}CO_2$. The ratio of ^{12}C to ^{13}C and ^{14}C in a leaf can be used to calculate the rate of photosynthesis and hence the capacity with which the plant extracts CO_2 from the atmosphere. The results of the outdoor research are being utilized to create highly complex climatic simulations. With these, for example, the scientists wish to calculate by how many degrees the global temperature will rise if – as is currently foreseeable – the commitments of the Kyoto Protocol are not fulfilled. Model calculations are aimed at showing whether the replanting of felled forests will reduce the CO_2 concentration of the atmosphere.

The results obtained so far indicate that old forests are indeed carbon sinks, while the young tree plantations replacing previous old timber tend to actually release carbon – above all, because they initially lead to a major upset in the biochemistry of the forest soil. The aim of the researchers is to have these discoveries – the knowledge that sustainable forestry is "rewarded" – to also be reflected in the Kyoto Protocol.

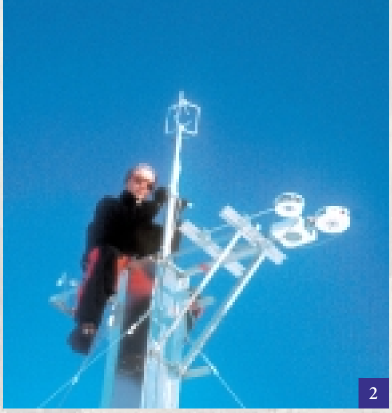

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Fig. 2:
Mounting work on a micro-meteorological measuring tower in the forest area of a biosphere reservation 300 km west of Moscow

3

Fig. 3:
Measurement of soil respiration in Siberia in the fall

4

Fig. 4:
Dendrochronology: Examinations of annual rings provide information on climatic events. (Photos: MPI for Biogeochemistry)

"Only by involving all strata of society in the discourse about global climate change will it be possible to implement climate protection in the future ..."

Prof. Dr. Ernst-Detlef Schulze, Director and Scientific Member of the Max Planck Institute for Biogeochemistry in Jena

Dr. Claudia Hillinger, Max Planck Institute for Biogeochemistry, Research Coordination
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Images of Cell Division

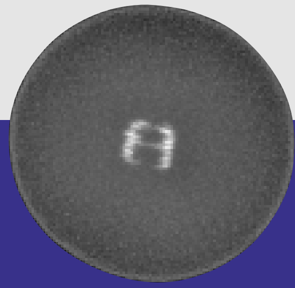
Yeasts and sea urchins played a major role in the discoveries for which the Nobel Prize in medicine was awarded in 2001. In December 2001, in Stockholm, the American scientist *Leland H. Hartwell* and the Britons *R. Timothy Hunt* and *Sir Paul M. Nurse* were honored for their discoveries of the cell cycle and its regulation. Cell division or mitosis is the fundamental phenomenon of cell multiplication. *Timothy Hunt* used sea urchins for his research of the cell cycle, and his examinations of cell cycle control were made using the Arbacia urchin.

Fig. 1:
Arbacia lixula sea urchin

In the beginning was the sea urchin

In 1875, *Oskar Hertwig* (1849–1922) – a student of *Ernst Haeckel* in Jena – demonstrated the fertilization of the ovum, one of the basic processes in biology, using sea urchins. He defined fertilization as the union of egg and sperm nucleus. The fertilization and cell division processes observed in sea urchins made this species well known as examination objects at quite an early date. Ever since, the spiny marine creature has been a popular research object and model system in cell biology.

It is very easy to obtain high quantities of egg cells and sperm cells from male and female sea urchins, mix them in a dish with sea water or right on the microscope slide and observe the events live under the microscope. Sea urchin eggs have no specific requirements, e. g. for precise temperatures or special culture chambers, they develop almost simultaneously and are therefore ideal for cell biology experiments.



"We determined the exposure times for fluorescence photos through trial and error over a whole series of exposures."

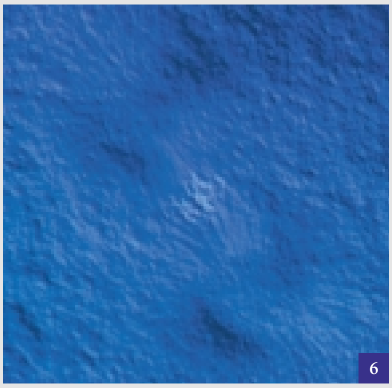
R. Timothy Hunt

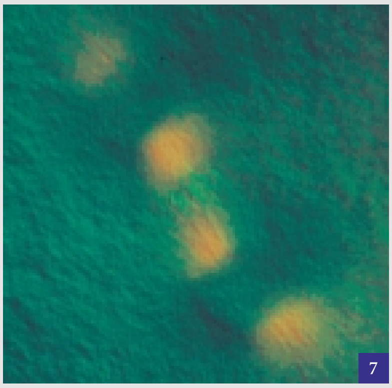
Regulation of the cell division is one of the pressing problems in cell and developmental biology. The cell division of living objects can be easily observed under the microscope in brightfield, darkfield and phase contrast illumination. Images of particularly high contrast are obtained with Nomarski-type differential interference contrast (DIC). The fine structure of the cell and the cell nucleus can be displayed using the DIC technique in combination with high-aperture objectives.

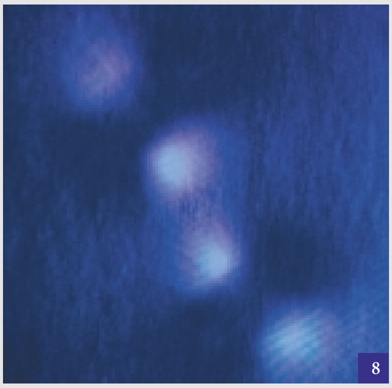
Figs 2 and 3:
Ovum of a sea urchin: one-cell stage, two-cell stage (**Planachromat** 16/0.35, DIC Nomarski)

Fig. 4:
Chromosomes in a sea urchin ovum (**Planapochromat** 63/1.4 Oil, DIC Nomarski) (Micrographs: *H. Gundlach* using a **Photomikroskop III**)

Fig. 5:
Mitosis of a sea urchin ovum Chromosomes fluorescence-labeled, Hoechst 33342 (Micrograph: *R. Timothy Hunt*)







Figs 6 to 8:
Metaphase of a sea urchin ovum, overlay chromosomes (DIC, microtubules) in polarization
(Micrograph: *Dr. H. Spring*, DKFZ Heidelberg, using an **LSM 410** Laser Scanning Microscope)

Proteins in control

In 1982, during his research work at the MBL (Marine Biology Laboratory in Woods Hole, USA), *Timothy Hunt* succeeded in achieving a major breakthrough in solving the problem of cell cycle control by isolating the so-called cyclins, a whole family of proteins controlling the cell cycle after fertilization. In addition to these biochemical analyses, microscopic procedures such as phase contrast and fluorescence were of major importance for the observation, documentation and analyses of the key components and their function during cell division. The use of confocal microscopy and digital fluorescence microscopy opened up new ways for the research of structure and function.

The first steps

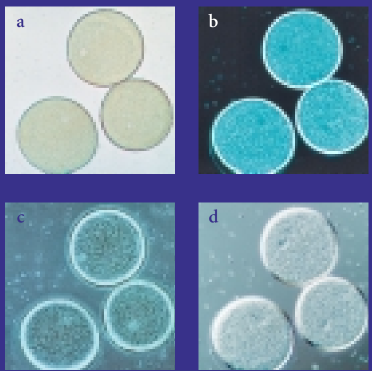


Fig. 9:
Daniel Mazia, one of the pioneers researching the cell cycle of the sea urchin, at the **Photomikroskop III** in 1976 during a marine biology course in Villefranche-sur-Mer.
Micrographs of sea urchins taken in traditional light microscopy:
a) brightfield, **b**) darkfield, **c**) phase contrast **d**) Nomarski-type differential interference contrast
(Micrographs: *H. Gundlach* using a **Photomikroskop III**)

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bel Prize

Pioneering Discoveries about the Cell Cycle

100 years ago, *Emil von Behring* – co-founder of modern immunology – received the first Nobel Prize in medicine. The 2001 Prize was awarded on December 10, 2001 to three scientists all working in the field of cell reproduction, albeit from different aspects. Two Britons – *Sir Paul Nurse* and *Timothy Hunt* – and the American *Leland Hartwell* were jointly honored for their pioneering, fundamental discoveries of key regulators and processes controlling the cell cycle. These are molecules and processes that play a key role in the growth and reproduction of cells and operate in the same manner in yeast cells, plants, animals and humans. Research on this subject had already started in the 1970s, and today's discoveries – which have largely increased our understanding of genotype alterations in tumor cells – now open up versatile ways of (early) diagnosis and treatment of cancer.

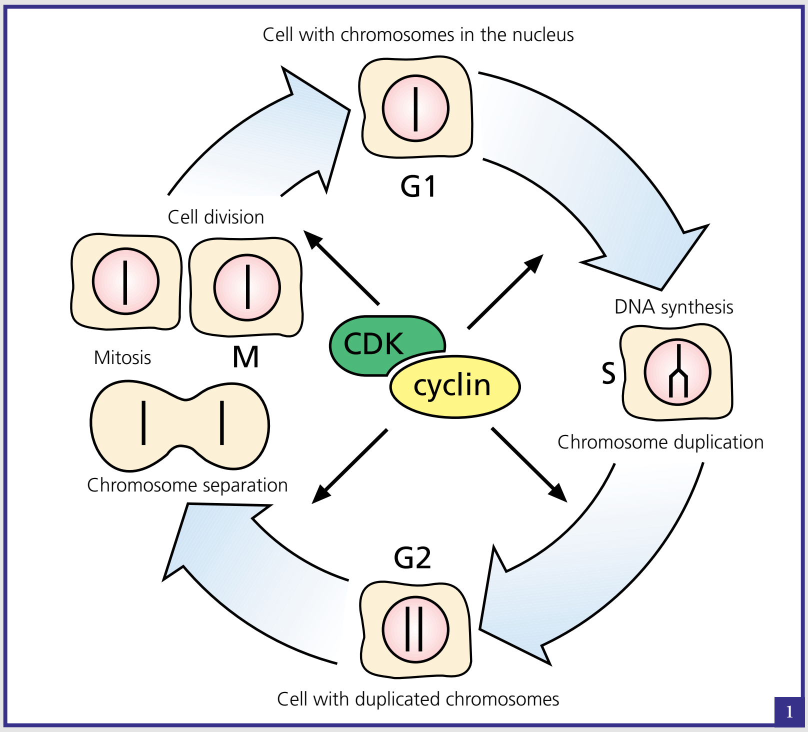

Fig. 1:
Cell cycle
(Nobel e-Museum)

Cell division – i. e. the multiplication of cells – is a fundamental process of life. It has been known for more than 100 years that cells multiply through division. An adult human being has approximately 100,000 billion cells, all originating from a single cell, the fertilized egg. During cell division, cells responsible for various functions originate from this single cell. Skin and nerve cells, but also cells of organs like the liver and kidney, perform specific functions which act together to regulate the entire organism. Almost all cells are continuously dividing to replace dead cells. In eukaryotic organisms, the fundamental process of cell division was highly conserved during evolution. Eukaryotic cells have their chromosomes located in a nucleus and separated from the rest of the cell.

The cell cycle consists of several clearly defined phases: growth of cells with chromosomes in the nucleus (G1 phase), DNA synthesis and chromosome duplication (S phase), preparation for cell division (G2 phase) and chromosome separation and division into two daughter cells (M phase). If the cells do not continuously divide, there is an additional resting stage (G0 phase) between phases M and G1.

Today, the findings already obtained by the three prize winners in the 1970s and 1980s are mainly used in cancer research. The discovery of key molecules in the cell cycle and the description of their function are the platform for preventive measures, diagnostics and the treatment of malignant tumors. Future prevention and treatment strategies can be based on the knowledge of cell cycle control.

Although the findings were obtained with three different model organisms, they all fit together like a puzzle and make a major contribution to understanding the cell cycle. The Saccharomyces cerevisiae *(Leland Hartwell)* and Schizosaccharomyces pombe *(Paul Nurse)* yeasts contributed to finding the "start" gene and the CDK (cyclin-dependent kinase) regulator component. The cell division processes in the sea urchin Arbacia *(Timothy Hunt)* led to the discovery of the cyclin mechanism.

Using genetic and molecular biology methods in yeast cell experiments, *Sir Paul Nurse* discovered CDK, one of the key regulators of the cell cycle. CDK activates further decisive cell cycle proteins via chemical modification (phosphorylation), thus influencing and regulating the cell division. Meanwhile, half a dozen different CDK molecules have been found in humans.

During cell division experiments using sea urchins, *Timothy Hunt* discovered the central protein molecules, the so-called cyclins, which regulate the CDK key component. Cyclin degradation during cell division is an important control mechanism of the cell cycle. The levels of cyclin vary periodically during the cell cycle. Today we know around ten different cyclins.

Using yeast cells as a model system, *Leland Hartwell* studied the genes controlling the cell cycle, the so-called CDC (cell division cycle) genes. Mutated genes led to the

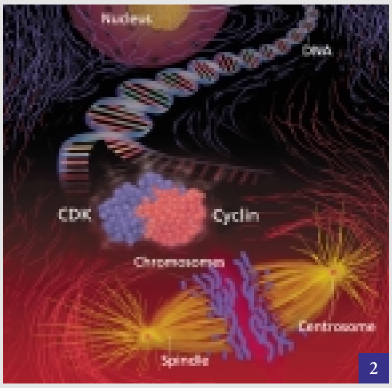

Fig. 2:
Function scheme of the cell cycle (Nobel e-Museum)

identification of about 100 genes specifically involved in cell cycle control. One of these genes, called "start" gene, plays a major role at the beginning of each cell cycle. After irradiation experiments, the checkpoint concept was introduced: the cell cycle is arrested when DNA is damaged and a DNA repair mechanism is activated before the cell cycle is continued. The concept also includes controls ensuring a correct order between the cell cycle phases.

Basic processes in the cell cycle therefore include the function of "duplicate hereditary material" on the one hand and the process of "cell division" on the other. Before a cell can divide, it must grow, duplicate the chromosomes – the carriers of the hereditary material – and equally distribute it to the two daughter cells. The various cell cycle phases must follow in the correct order and be precisely coordinated. The sum of all these single phases coordinates the cell cycle. If cell cycle components are lost and/or mutated, this may often lead to uncontrolled cell division. Even minute defects in the cell division phases can contribute to the development of tumors. And single defective cell division genes may be carcinogenic.

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Fig. 3:
Nobel Prize Ceremony 2001. From left to right: Timothy Hunt, Sir Paul Nurse, V. S. Naipaul, George A. Akerlof, Michael Spencer (Photo: dpa)

bel Prize

A Visit to Sir Paul Nurse – Winner of the 20

***Sir Paul Nurse* is interim CEO of Cancer Research UK, recently formed by the merger of the Imperial Cancer Research Fund (ICRF) and the Cancer Research Campaign. The 52-year-old biologist studied at the University of Birmingham from 1967 until 1970. Even in these early days he received his first prize, the John Humphreys Memorial Award in Botany. In 1973, *Paul Nurse* graduated with a degree in cell biology and biochemistry from the University of East Anglia. He held various scientific posts in a number of institutes, including Sussex and Oxford and Switzerland, where he worked at the Microbiology Institute of the University of Bern. He was also a visiting professor at the University of Copenhagen. He worked at the ICRF in London between 1984 and 1987 and in 1998 received the prestigious American Lasker Award. He was knighted in 1999. *Paul Nurse* has been married for 30 years and has two daughters.**

***Paul Nurse* started using Zeiss products very early in his career. He first became familiar with the Universal microscope in 1973, after finishing his Ph. D. and commencing employment at *Murdoch Mitchison's* laboratory in Edinburgh – in the days of *Michael Swann*. He has used microscopes from Zeiss ever since and has been particularly impressed by the excellent fluorescence features of the latest Zeiss microscopes.**

INNOVATION visited *Sir Paul Nurse* in his laboratory at Cancer Research UK in London in April 2002 and met a kind, warm-hearted person and scientist who sacrificed a few moments of his precious time to give us some insights into science, his life as a scientist and into life behind science. Although he holds the CEO position at Cancer Research UK he has retained his direct ties with science and his colleagues. For example, he has direct access to his laboratories and staff from his office and study.

Fig. 1:
Happy Nobel laureate
Sir Paul Nurse
(Photo: dpa)

Is there any need for a rethinking process in the biological sciences? Away from narrowly defined disciplines towards a multidisciplinary approach? The work of ELSO (European Life Scientist Organization) is exemplary in this field. What about interdisciplinarity?

That's really important for the future. I was actually a founder member of ELSO being involved in the committee setting it up, but I'm not helping to run it because I have so many other things to do.

My own work, although confined to yeast, covers a lot of biological problems. It is focused on the cell cycle and spatial organization in the cell. I think the interdisciplinary approach is very, very important in biology. I think we stand at a real crossroads because we can combine together all sorts of techniques, of which microscopy is an absolutely essential one. What has been achieved in the last ten years is totally revolutionizing. What we can do with *time lapse* and *real time* microscopy is really impressive. And that is part of the interdisciplinary approach. But I think we need to push that even further. We are getting closer to understanding the wonderful phenomenon of life represented at the level of the single cell.

What is your relationship with your two co-winners, Tim Hunt and Leland Hartwell?

I'm close to both but have never worked formally with either of them. I've known both for 20 years or more, *Lee (Hartwell)* for nearly 30 years. And I've had many, many conversations with them. *Tim (Hunt)* is a colleague here at Cancer Research UK. We frequently meet, and have a close personal relationship but have never carried out joint projects or joint programs.

Now that six months have passed since you received the Nobel Prize, is your life getting back to normal?

No. The Nobel Prize has meant quite a big change, because suddenly I've been overwhelmed with many requests to do things. Since it was announced I must have had about two invitations a day to speak at or attend various events. That's been very difficult to manage.

The second aspect is that suddenly people want to talk to you. The newspapers contact me, and the really scary thing is that they listen to what you say! They think you have something important to say about everything. I know about some things and nothing about others. But as a Nobel Prize winner you've suddenly become an expert in everything, so you have to be careful about what you say.

Two years ago you were knighted. Did this change your life in any way?

No. Knighthood barely makes any difference at all. You have no responsibilities with it, you have no extra job, nothing happens after you've done it. The difference is that you have a title, which you can use or not use. In my case, I don't use it professionally as a scientist or personally, but I do use it professionally for fundraising.

Was there any profession you dreamed of in your childhood?

I have always been interested in science. Originally, I was interested in natural history, and astronomy, just observing the world, so I think science was always on the agenda. But I also quite liked the humanities as well. For a while I was uncertain whether to go towards English and English literature, or science. I was particularly interested in the theater at the time, and that was a difficult decision. Being a lecturer in science is quite theatrical, and so I thought I'd satisfy that need!

Was there any specific event which made you decide in favor of biology in the end?

What I thought when I was exposed to the different natural sciences – and I was brought up in the sixties, when it was all pretty traditional – it seemed all the answers were there in physics and chemistry, whereas – when you came to biology – there seemed to be still lots of questions. And lots of questions that you could even already ask at 17 or 18. If you were interested in natural history, you could go out and do a study, and this was all completely new. And it was the ability to explore and discover things myself, which was even possible already at that age that attracted me more towards biology.

Did you ever have the feeling in those early days that your decision to study biology was wrong?

No, never. I'd had a bit of uncertainty about what area of biology I should choose. When I was a student I was more attracted at the beginning towards ecology and the natural environment than towards molecular biology. However, I switched pretty quickly when I realized how difficult it was to do good studies in that sort of area. And my mind found it too "floppy" to feel happy with it. Though I thought it was important, my psychology wasn't good for ecological studies. I was happier with the "harder" molecular biology. Harder, not in the sense of more difficult, but in the sense of more precise.

We know that you are married and have two children. How difficult is it for you to bring scientific activities and private activities under one roof? How much time do you have to spend with your family?

That's been really difficult. Being a scientist and a senior administrator running a big organization makes huge demands on my time. And it's always been difficult to find enough time to balance all of these activities. However, I do try and keep my weekends as free as possible. My wife teaches small children. My own children are now grown up. One of my daughters is an assistant sports producer on a TV program about soccer. The other one is a scientist doing a Ph. D. in theoretical particle physics.

What hobbies do you have when you find the time?

I do find time. Because I think if you just do your work, you end up not being as good. Not only because you're not relaxing, but also because you're too narrowly confined. So, apart from wanting to do other things as a human being, I also think it's good for my work.

One hobby is being a pilot. I'm both a glider pilot and a powerpilot. And I'm also an amateur astronomer. I'm interested in a number of other things, like hillwalking, natural history, birdwatching. And the theater, still.

Just one more question: In the press, when you got the Nobel Prize, you said you were going to buy yourself a motorbike. Have you bought it yet?

Yes, I have. I always have had a motorbike, but I got myself a bigger and newer one about a month ago!

Credit Where Credit is Due

Two Nobel laureates receive the Carl Zeiss Lecture award

The Carl Zeiss Lecture was created in 1990 by the Microscopy Division in order to increase the possibilities of the German Society of Cell Biology (DGZ) to invite recognized and prominent scientists to its annual convention. In 1993 the Carl Zeiss Lecture was converted into an award which is presented during the opening event of the DGZ annual meeting and requires the winner to give a lecture at the beginning of the event. With the Carl Zeiss Lecture, the DGZ honors outstanding international achievements in cell biology in the field of light and electron microscopy.

The award-winners are selected by a committee including the President of the DGZ, the President of the convention and representatives of Carl Zeiss. All members of the DGZ can submit proposals for future winners of the Carl Zeiss Lecture to the President of the society (http://www.zellbiologie.de/preise/)

There was more than one novelty at the presentation of the 2001 Carl Zeiss Lecture. The first novelty was the event itself. For the first time ever, the German Society of Cell Biology and its French equivalent organized the Franco-German Meeting of Cell Biologists in Strasbourg, France from November 7–9, 2001. The second novelty was that there were two prize-winners for the first time. Thirdly, the fact that both winners were Nobel laureates was also new, although one of them did not in fact receive his Nobel prize until after receiving the Carl Zeiss Lecture award.

For the Franco-German Congress of Cell Biologists in Strasbourg, *Professor Dr. Günter Blobel*, winner of the Nobel prize for Medicine in 1999, was selected to receive the award. "Protein Targeting" was his subject. Unfortunately, he was unable to come to the event from the USA and had to cancel his attendance at short notice.

A decision had to be made very quickly. As the sponsor of the Carl Zeiss Lecture, Carl Zeiss decided to present a second award to the Briton *Prof. R. Timothy Hunt* of the Imperial Cancer Research Fund (ICRF) in London, England. The president of the German Society of Cell Biology succeeded in inviting *Prof. R. Timothy Hunt* to give the Carl Zeiss Lecture at short notice. In December *Hunt*, together with *Sir Paul Nurse* and *Leland H. Hartwell*, received the 2001 Nobel Prize for Medicine for his work on cell division. As a result, the participants were able to enjoy two interesting lectures: that of *Günter Blobel* on video, transmitted from the USA, and that of *Timothy Hunt* live.

Fig. 1:
Official event poster of the Franco-German Society of Cell Biology in Strasbourg, November 2001

Fig. 2:
Prof. Dr. Günter Blobel, winner of the Nobel Prize for Medicine in 1999

Fig. 3:
Prof. Timothy Hunt with the certificate of the Carl Zeiss Lecture (Photo: *John Nicholson*)

Ernst Abbe Lecture 2001

On the occasion of the international workshop "New Tools for In-Situ Research of Macromolecular Interactions", which took place in Lyon/France on October 16 and 17, 2001, the Ernst Abbe Lecture award was presented to *Professor Thomas M. Jovin*. The Ernst Abbe Lecture is a scientific award that was presented for the first time in September 1996 by the Royal Microscopical Society (RMS) and Carl Zeiss during a scientific symposium of the RMS in London to mark the 150th anniversary of the Carl Zeiss company.

Thomas M. Jovin is Chairman of the Department of Molecular Biology at the Max Planck Institute for biophysical chemistry in Göttingen. The congratulatory speech for *Thomas M. Jovin* was given by *Prof. M. Robert-Nicoud*, who has worked closely together with *Jovin* in Göttingen for many years. The subject of his lecture during the workshop was: "Finding and following signals on and in the cell using the fluorescence microscope".

Thomas M. Jovin numbers among the scientists who used one of the first laser scanning microscopes from Carl Zeiss (Fig. 1). Originally, the laser scanning microscope was developed for the materials sciences. Basic applications of the laser scanning technique for both biology and medicine (Fig. 3) were developed around the mid-eighties. The general article from 1985 published in the prestigious American Science magazine listed possible fields of application. The laser scanning microscope was used in a wide variety of experiments in transmitted-light phase contrast, Nomarski-type differential interference contrast (DIC) and epi-fluorescence. According to *Thomas M. Javin*, the major technological benefits even at that time included the "...so-called opto-electronic zooming permitting the magnification to be increased continuously up to a factor of 10x without any loss in contrast and resolution...". This gave new insights into the fine structure of entire cells and also of cell components, including living ones, such as nucleus, endoplasmatic reticulum and chromosomes (Fig. 2). Major opto-technical progress has also been made in traditional and confocal fluorescence microscopy. Increasingly, the single fluorescence techniques were supplemented and replaced by double and multifluorescence techniques. This enabled differently fluorochromed cell components to be defined clearly and easily in one single step and be assigned to cellular structures.

Today, after 20 years of experience in laser scanning microscopy, this technology is being used increasingly in the research of molecular structures and functions. The discovery of GFP (Green Fluorescent Protein), a natural fluorochrome present in marine life forms, and its variants has now permitted various cell components in living cells and tissues to be visualized simultaneously, so that their creation, degeneration and function can be followed even over long periods of time (Life Time Imaging).

Fig. 1:
Prototype of the first **LSM** from Carl Zeiss (1982). Exhibit in the Deutsches Museum in Munich

Fig. 2:
Giant chromosomes of the larva of the *Chironomus thummi* midge in Nomarski DIC, overview and zoomed magnification (Micrograph: *Thomas M. Jovin, Prof. M. Robert-Nicoud*)

Fig. 3:
Ernst Abbe Lecturer *Prof. Thomas M. Jovin* (center), *Prof. M. Robert-Nicoud*, Grenoble (right) and *Dr. H. Gundlach* (left), Carl Zeiss (Photo: *Leif Lissmyr*)

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High Resolution Optical Microscopy

Dr. Stefan Hell receives the 2002 Carl Zeiss Research Award

The Ernst Abbe Fund in the Donors' Association for the Promotion of Science in Germany has presented the Carl Zeiss Research Award for the seventh time. The prize is awarded for outstanding and pioneering achievements in basic research and applications in the field of optics. From the numerous papers submitted this year, those of the physicist *Dr. Stefan Hell* of the Max Planck Institute of Biophysical Chemistry, Göttingen, Germany on the subject of high resolution, optical microscopy were selected by the award committee.

The now almost 40-year-old *Stefan Hell* studied physics at the University of Heidelberg, Germany. After receiving an excellent degree in 1987, he completed his dissertation with the distinction "summa cum laude" under the guidance of *Prof. S. Hunklinger* in 1990. Even in these early days, the central theme of *Stefan Hell*'s work that was to dominate all his later research was already evident. The subject of his dissertation was "The Imaging of Transparent Microstructures in the Confocal Microscope". This was followed by various scientific posts in Germany and abroad. Via a postdoctoral position in the Light Microscopy Group at the European Molecular Biology Laboratory (EMBL) in Heidelberg, Germany and posts in Turku, Finland and Oxford, UK, *Stefan Hell* came to Göttingen, Germany in 1997. Here, he heads the independent "High Resolution Optical Microscopy" group of the Max Planck Institute of Biophysical Chemistry. In 2001 *Stefan Hell* and *Thomas A. Klar* together received the Helmholtz Prize for the development of an optical technique that allows the detailed visualization of even the smallest structures in the interior of a cell. He was also awarded the ICO (International Commission for Optics) Prize in 2000.

Stefan Hell has focused his attention on finding methods and ways of enhancing the resolving power of the optical microscope in order to expand its possible fields of application in the specialist areas of the life sciences. Important scientific results and methods developed by him include the STED concept ("STimulated Emission Depletion" Microscopy), 4π confocal microscopy and 3D resolution in the range of 100 nm.

The award ceremony took place during the annual convention of the German Society of Applied Optics (DGaO) in Innsbruck, Austria in May 2002. In the presence of Carl Zeiss Member of the Board *Dr. Norbert Gorny*, *Prof. Dr. Werner Martienssen* made a speech in *Stefan Hell*'s honor and presented the award to him.

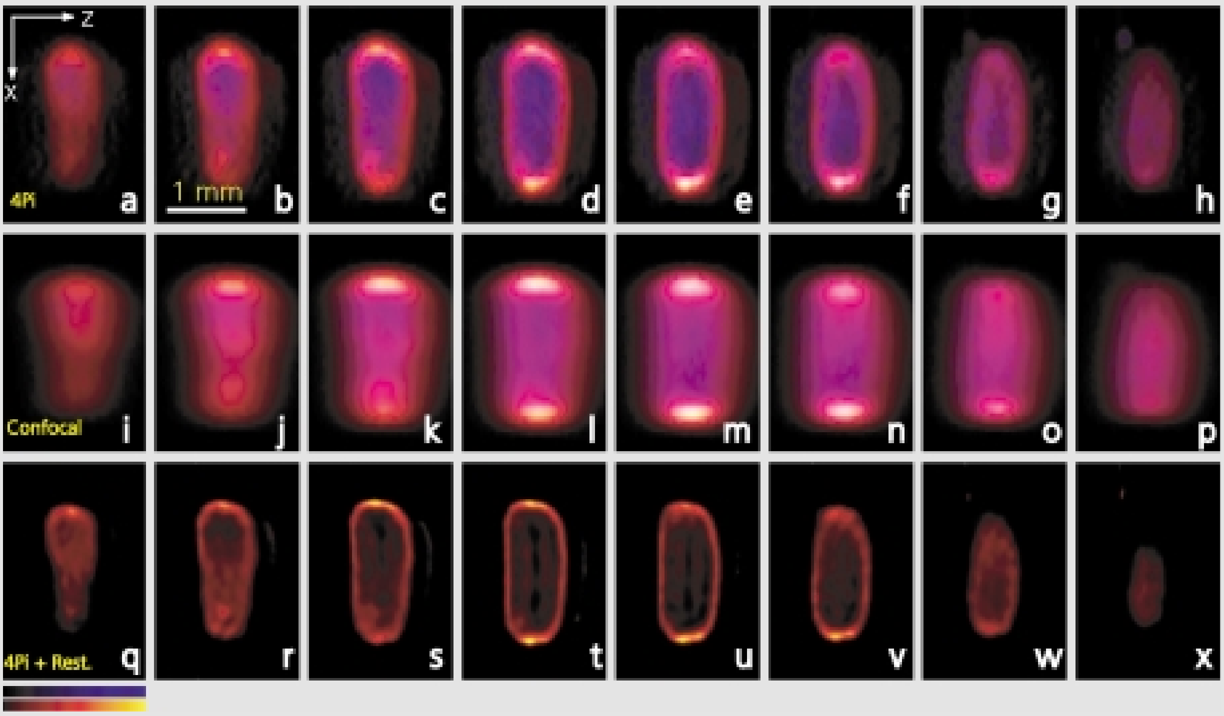
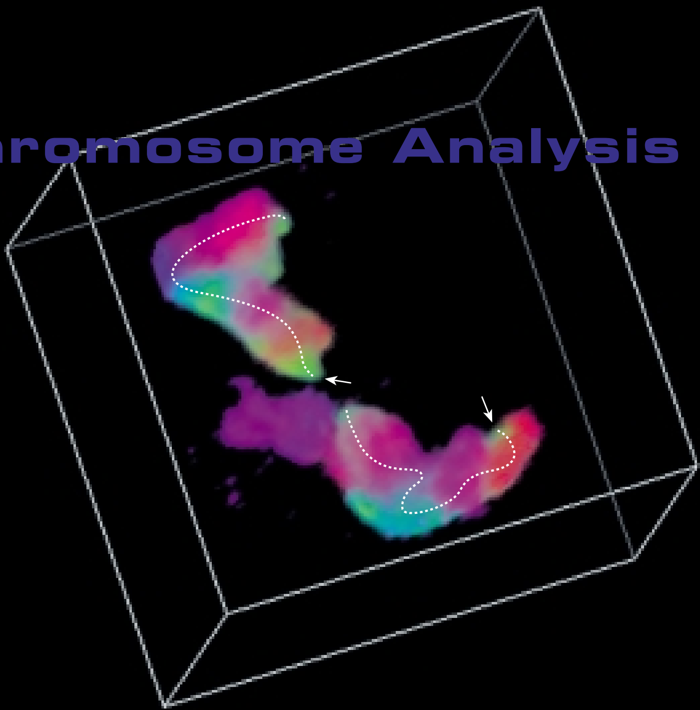


Photo:
Optical sections (xz images) of an *Escherichia coli* bacterium, whose membrane has been stained with the dye FM1-43 (red) and nucleoid with DAPI (blue): the sections join to form a 3D image if they are stacked in the y direction. Z denotes the optical axis. The dimensions are 2.7 x 0.8 x 1.8 μm^3 in the x, y and z directions. (a-h) are 4π confocal images. (i-p) are the confocal images taken in direct comparison to this. (q-x) are 4π confocal images of the bacterium membranes which were restored in accordance with the Richardson-Lucy algorithm in order to achieve a further increase in resolution.

All-round Chromosome Analysis



During cell division, the hereditary substance in the chromosomes is passed on unchanged from one generation to the next. Defects occur in spite of the high precision with which the genes are copied and distributed to the daughter cells generated. On the one hand, the resulting changes in genetic features are required for evolution, but on the other hand they often lead to diseases which are incurable for the time being. Research in human genetics aims at being able to recognize chromosomal irregularities and diagnosing genetically caused diseases at an early stage.

Fig. 1:
Two chromosomes 5 in the cell nucleus of a human lymphocyte. The ends of the short arms are marked with an arrow and the axes of the chromosomes with a dotted line. The **LSM 510 META** permits chromosomes to be examined 3-dimensionally in a new quality. The better resolution obtained through multicolor technology permits a differentiated structure analysis. Specimen: *Johannes Lemke* and *Thomas Liehr*, Institute of Human Genetics and Anthropology, Friedrich Schiller University, Jena.
Micrograph: *Peter Ullmann*, Carl Zeiss

Uwe Claussen

Normally, chromosomes only become visible if a cell divides, i.e. if two daughter cells are generated from one mother cell. In particular, chromosomes in the metaphase division stage can be analyzed easily and routinely. Their number, shape and length, the position of their centromeres allowing classification in a long and a short arm, and their structure, i.e. the type of their banding pattern, can be examined in this stage. However, all these characteristic chromosomal structures could not be recognized so far in the interphase nucleus, i.e. in the status in which the cell performs its defined work.

The **LSM 510 META** laser scanning microscope and the "multicolor banding" (MCB) technique, a special molecular cytogenetic tool for the display of chromosomal DNA, has recently made it possible to view chromosomes in the interphase nucleus in three dimensions. In Fig. 1, the structures of the two chromosomes 5 in the cell nucleus of a human lymphocyte can be clearly recognized. The short arms of both chromosomes 5 point to the right, their ends are dyed green and then orange (arrow), a section marked violet follows in the long arm, and then a green and blue one in the center of the long arm. The end of the long arms of both chromosomes 5 is marked by a reddish violet area and finally by a green band. The blue section lying between the two chromosomes is not any specific material of chromosome 5. When comparing the structure of both chromosomes 5, you will see that the order of the color bands is identical. Although the chromosomes lie in the nucleus in a curved position, you can see that the DNA structure and shape of chromosomes in the interphase nucleus are similar to metaphase chromosomes. Future examinations will reveal whether the 3-dimensional display of chromosomes in the interphase nucleus using the **LSM 510 META** laser scanning microscope will also permit chromosome anomalies to be recognized. The first results in this area are promising. Once this can be achieved with sufficient diagnostic reliability, the lengthy cultivation of cells can be dispensed with in future chromosome analyses. Such analyses will then also be possible with cells which can no longer divide, which would open up new areas of activity both in research and diagnostics.

Prof. Dr. med. Uwe Claussen, Director of the Institute of Human Genetics and Anthropology, Friedrich Schiller University, Jena.
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mti-n.mti.uni-jena.de/human.htm

Fig. 2 (image sequences):
3D display of chromosomes in the interphase nucleus from different perspectives

The Course is Set for the Microchips of the

Konrad Ahrens

The prototype of high-performance optics for the fabrication of microchips of the next-but-one generation has now had its premiere. In the radiometry laboratory of the German Physical-Technical Institute (PTB) at the Berlin BESSY 2 electron synchrotron, chip features of as small as 50 nm were patterned for the very first time in Europe using the Micro Exposure Tool (MET) from Carl Zeiss SMT AG.

With more and more stationary and mobile intelligence, microchips are making our everyday lives easier. To achieve this, they must perform an increasing number of functions and process more and more data in ever shorter times, at any time and in any place, and with less electrical energy than in the past. Currently, the processing speed of the processors doubles every four years, and the capacity of memory chips increases by a factor of 10 every five years. The ITRS (International Technology Roadmap for Semiconductors) quantitatively plans the stages of this development in advance. Whereas the feature sizes of the current function elements are still around 130 nm, they will decrease to about 50 nm or even 30 nm toward the end of this decade.

The principle used to fabricate these components is similar to that used in slide projection: Light beams image the microstructures on masks on the silicon surface of a wafer. Each exposure is followed by subsequent chemical treatment (microlithography). The demands made on the precision of the projection optics in this process are enormous. In addition, with increasingly smaller features, light with increasingly smaller wavelengths must be used for projection.

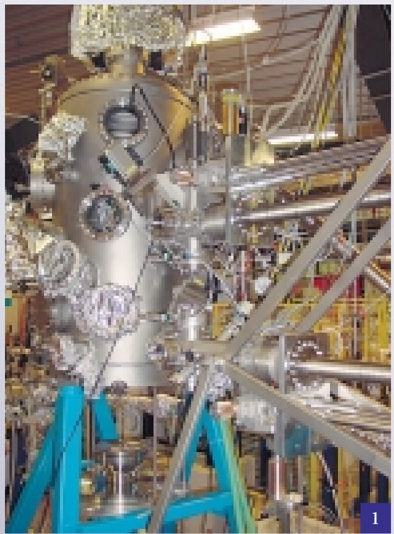


Fig. 1: Experimental setup for testing the Micro Exposure Tool (MET) for Extreme UV Lithography (EUVL). The MET is located in a large metal vessel; the trans-radiated volume is a vacuum.

The market focuses on extreme UV lithography

Research laboratories, manufacturers and suppliers are currently working at full stretch on solutions for the production of semiconductors of the generation after next. "Most of the market participants are focusing on extreme UV lithography (EUVL)," said *Dr. Herrmann Gerlinger*, CEO of Carl Zeiss SMT AG. Only with UV light of an extremely short wavelength (13.5 nm) will it be possible to project the microstructures of the future semiconductor generation from the mask on to the wafer with the resolution required and to achieve high productivity at the same time. The MET successfully tested in Berlin uses this technology as a basis. The development was funded by the International SEMATECH (ISMT, an international association of chip manufacturers) and by the German Federal Ministry of Education and Research.

Mirrors instead of lens elements

The materials usable for optical systems do not transmit extreme UV light. For this reason, the imaging beams can no longer be directed by refraction through the lens elements, but only by reflection from mirrors. The aspheric mirrors made for these high-performance optical systems are aligned to a precision of a few millionths of a millimeter. Their surface figure (admissible deviation from the mathematically required surface) and the surface roughness are approximately three times the diameter of a hydrogen atom. This ensures the correct transfer of the structures on the mask to the chips, enables high contrast for edge-to-edge imaging and high reflectivity of the mirror surface. In addition, the demands for short exposure times and high throughput, i.e. high productivity, in chip fabrication are met. A comparison: in lens elements used in reflex cameras, the admissible deviation from the surface accuracy required is 50 to 100 times greater.

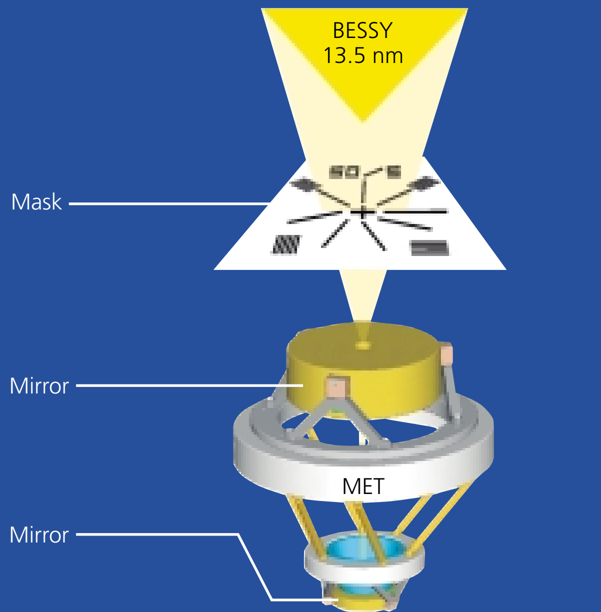
...today

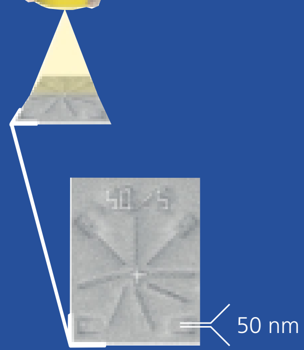
Future details

The next step

Together with its Dutch partner ASML, Carl Zeiss is developing the successor to MET within the framework of the Extreme UV Alpha Tool Integration Consortium (Extatic). *Noreen Harned*, VP of ASML and Extatic Program Manager, explains the goals of the European MEDEA+Consortium: "ASML is the only company in Europe developing a full-field exposure tool. We are well within our time schedule for starting volume production in the year 2007. The status of development is largely the same in Europe as in the USA, but ahead of Japan. The focus is on three critical areas – tool development, lens manufacture and development of radiation sources. The European activities are concentrated on the research and developments necessary to make EUV lithography a marketable technology. ASML will then provide the members of EUV LLC (an American R&D consortium launched by ISMT and Intel in 1996) with beta tools. We are the only manufacturer who has announced plans for the delivery of the first beta EUV tools."

The new optics used in the beta EUV tool will work with a considerably larger image field than MET and have six instead of two mirrors, which will also be markedly larger. Carl Zeiss SMT AG will again improve the surface accuracy and surface quality of the mirrors and the accuracy of the overall alignment over MET to be able to achieve the targeted resolution of 30 nm. MET will be used in a lab production system with an optimized set of mirrors by the International SEMATECH to develop photoresists which can be used with EUV in the fabrication of semiconductors.





Premiere of EUVL in Europe

The production of high-performance optics for the fabrication of the next-but-one generation of semiconductors is feasible. This has been demonstrated by the test of the Micro Exposure Tool (MET) for Extreme UV Lithography (EUVL) performed in the radiometry laboratory of the German Physical-Technical Institute (PTB) at the Berlin electron synchrotron using UV light with a wavelength of 13.5 nm.

The BESSY radiation projects the mask features on to light-sensitive photoresist via two mirrors. 70 nm and 50 nm structures are resolved.

Illustrations on the left and bottom right: Lithography optics for today and the years ahead.
Left: Present-day **Starlith®** lens.
Bottom right: The prototype for EUVL tested in Berlin – for the years ahead. The Micro Exposure Tool (MET) with high-precision mirrors has been developed by Carl Zeiss SMT AG in cooperation with the Lawrence Livermore National Laboratories, USA

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the years ahead...

Taking a Closer Look at Teeth

Anke Biester

The most agreeable visits to the dentist are those which end without drilling. However, even if the crown or the root of a tooth need to be treated, this is no reason for being anxious. In the last 15 years, much has changed in the dentist's office; elegant and long-term solutions for tooth conservation and replacement have become possible. The impetus for these quality improvements and new treatment methods has been given by loupes and surgical microscopes.

Unfortunately, it will not be possible to dispense totally with drilling in the long term. However, dentists can treat teeth and gums in a much gentler way than was possible some years ago. Despite drilling, more substance remains on the tooth, and wounds resulting from surgery are much smaller today. For patients, this means less pain, reduced healing times and greater satisfaction with the outcome. The possibility of obtaining a magnified image of the teeth using a head-worn loupe or a surgical microscope has been and continues to be an absolute must for this development.

Simple visual devices were already used in many medical areas, such as surgery, 100 years ago. As far back as 1953, the company Carl Zeiss developed a surgical microscope which laid the foundations of modern microsurgery with its magnification system and suitable illumination. However, it was not until the last ten years that microscope technology made its appearance in the dentist's office – with the aim of achieving the best possible precision in treatment and the best possible protection of healthy tissue.

Fig. 1 (in the background):
OPMI® PRO magis
dental microscope

Fig. 2:
Insection of apical
regions

Clear visibility of all root canals

An important area where the surgical microscope is used is root treatment (endodontics). Only the magnification of up to 25x provided by the microscope makes it possible to visualize even the finest details, such as cracks in the tooth, fine root canal orifices, additional lateral canals or other structures. Thanks to the increased magnification and shadow-free illumination of the surgical field, the field can be seen much more clearly and the instruments guided much more precisely. *Dr. Syngcuk Kim*, Director of the Microscope Training Center and Chairman of the Endodontics Department at the School of Dental Medicine of the University of Pennsylvania, published a clinical study on 94 endodontic cases treated under the microscope (Journal of Endodontics) which showed that a success rate of 96 % was obtained in follow-ups performed one year later. The importance of the surgical microscope for endodontics is undisputed. The American Dental Association requires the students enrolled in its accredited schools to be proficient in the use of this instrument before receiving a degree in endodontics. The surgical microscope is also gaining importance in dentists' offices in Germany.

"To me, the magnifying visual devices from Carl Zeiss are indispensable for precise diagnosis and improved treatment."

*Dr. med. Josef Diemer with his **OPMI® PRO magis** surgical microscope in his office in Meckenbeuren, Germany*

2

Reliable diagnosis and an improved standard of care

The surgical microscope makes it possible to achieve increased precision in general diagnosis, thus improving the quality of treatment. For example, only visual inspection using magnification ensures that the new

Fig. 3:
Dr. Wolf Richter, Munich, uses the **OPMI® PRO magis** dental microscope for treatment in his office. His assistant supports him on the stereo coobservation tube.

filling materials meet the quality standards required, as the precision with which plastic-reinforced ceramic fillings are inserted in the tooth is a crucial factor. It is this precision which prevents caries from developing under the fillings – a problem frequently occurring with non-amalgam materials. *Dr. Josef Diemer*, specialist in periodontics and endodontics, says: "Filling materials have been considerably improved. Dentin adhesives alone are now entering their fifth generation. It is really no longer necessary to use amalgam." He works almost constantly with a loupe providing 4x magnification. "In fact, I wear it all day." To *Diemer*, the microscope is an indispensable tool for performing checks and fine corrections at the end of therapy, root treatments and, of course, surgical procedures. When suturing wounds, for example, after implantation, *Diemer* puts his comfortable head-worn loupe back on: "The head-worn loupe enables me to make more precise sutures, as the suture material may be considerably thinner. For the patient, this means better and faster healing." Since the beginning of this year, he has had a head-worn loupe with an integrated illumination system which makes his work easier: "The direct illumination provides improved visibility and enables me to work with increased precision."

Prophylaxis performed by dentists and patients

These costs, however, are not borne by health insurance schemes in many countries – which is why many patients prefer to do without prophylaxis. "Here, health competes with the car or a vacation," Diemer states from his own experience. Many are still shirking from cleaning their teeth regularly and thoroughly, in particular with dental floss. It is a good thing that the dentist can keep the damage within limits using state-of-the-art technology.

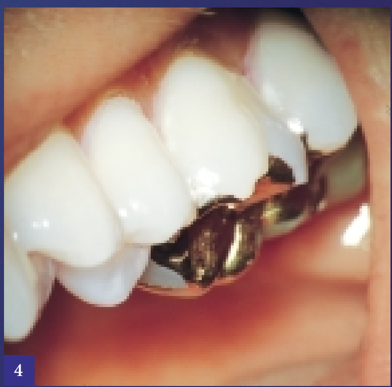

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Fig. 4:
Fitting a crown with the utmost edge precision

Fig. 5:
Massive undermining caries with a distal crack in the enamel

In addition to enhanced technology, prophylaxis plays a crucial role in dental health. For some years now, a visit to the dentist has not only included a check of the teeth for holes, but also the removal of tartar and providing patients with instructions for the correct cleaning of their teeth at home. Anyone who cleans his teeth regularly and thoroughly demonstrably prevents caries and periodontosis. *Dr. Josef Diemer* strongly recommends comprehensive prophylaxis including not only the cleaning, but also the fluoridation of the teeth.

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Take Your Pick – At Home!

Ingolf Zera

The comments are usually meant well: "Yes, not bad, but they'll take some getting used to." Or: "They're different, yes. But don't you think rimless frames would suit you better?"

The moment of truth

Anyone who has ever bought a pair of glasses knows that there is always a moment of truth: when you show them to your partner, friends or relations for the fist time. This determines how you will feel wearing their new glasses in future – that is, if you ever want to put them on again!

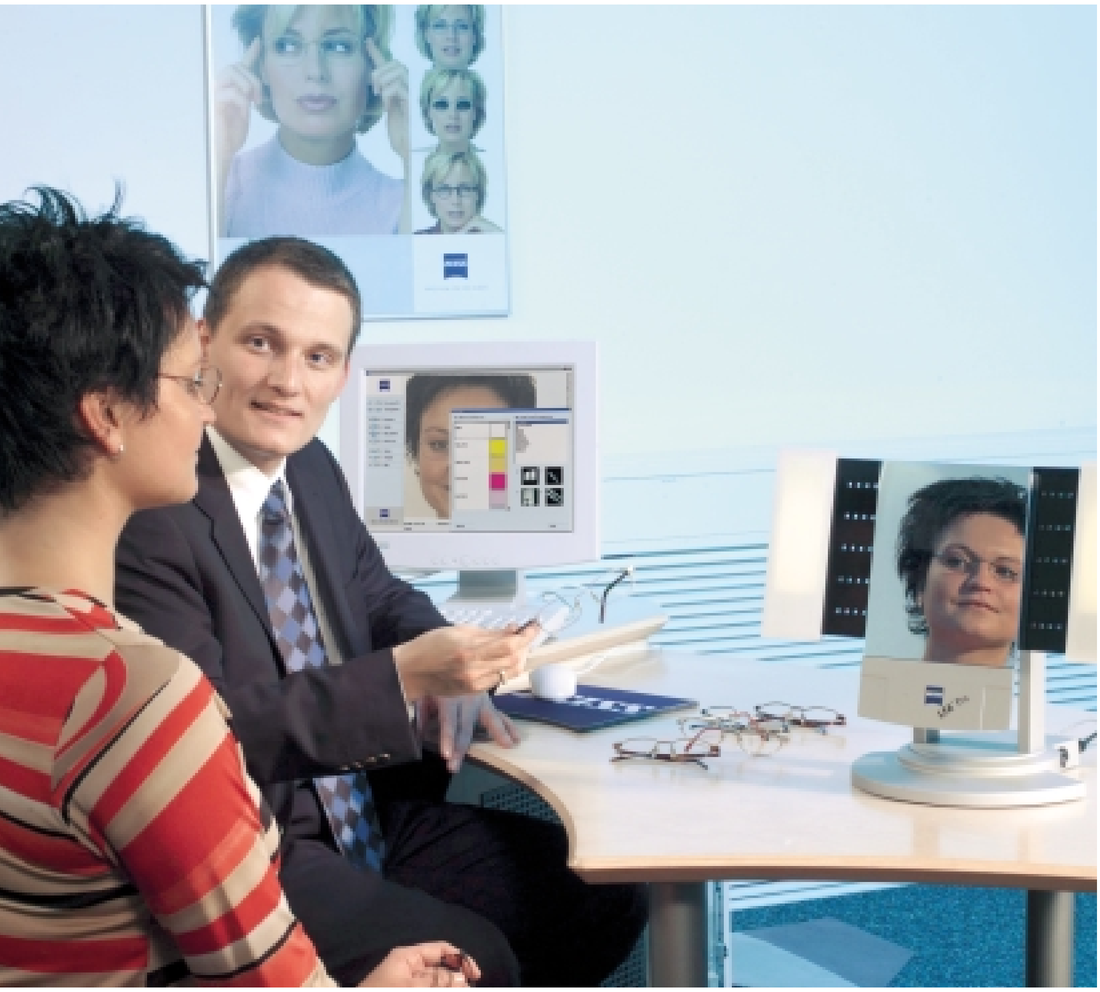


Fig. 1:
Eyecare professionals use **LFA Pro** to advise their clients on their new eyeglasses – selected in the peace and comfort of the client's own home

This dreaded moment has now lost its horror. The reason is the **Lens Frame Assistant LFA Pro** from Carl Zeiss. It can be used to try out innumerable eyeglass frames – and all in the comfort of your own home until even the fussiest member of your family is satisfied.

This pioneering system does not mean that you no longer need to go to your eyecare professional. He or she will not only give you professional advice, but will also photograph you. While you look into the mirror, the **LFA Pro** takes a photograph of you through the glass. The result is a digital portrait of outstanding quality.

This is exactly what is needed to allow your eyecare professional to offer you a huge selection of eyewear while you are still on his or her premises. Using a digital catalog, the eyecare professional can insert any selected frame in the portrait. You will see immediately if a certain shape of frame suits you, whether the color is right, or what cosmetic benefit is provided by a lens with an antireflective coating. The price limit can also be settled beforehand.

Targeted and time-saving

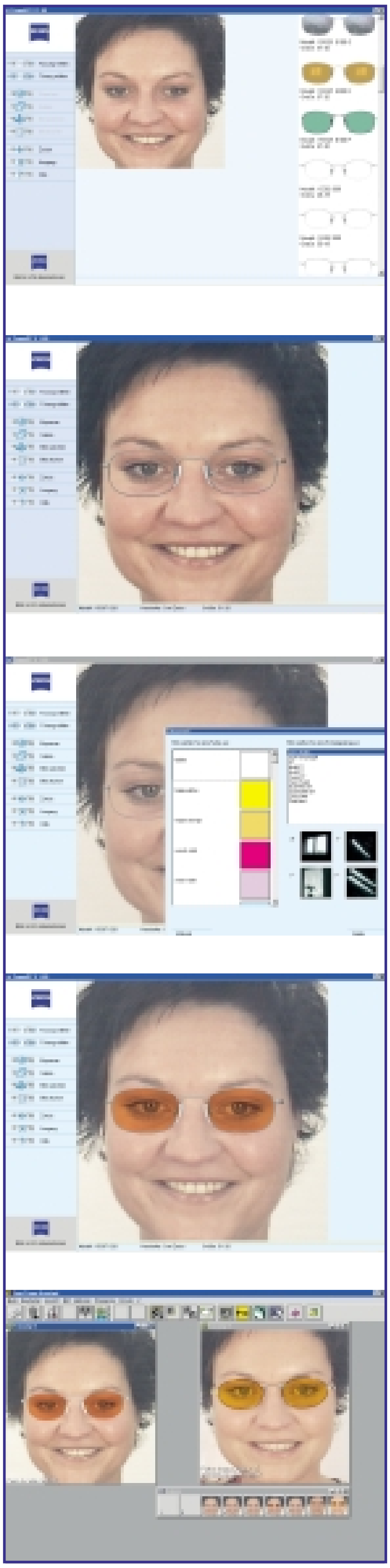
The benefit for eyecare professionals: they can advise their clients in a more targeted and time-saving way, and they have an extremely large range of models to offer.

The benefit for clients: they are no longer dependent on the products stocked by the individual eyecare professional or on what he or she happens to pull out of a display or showcase. They can devote their full attention to the eyeglass frames that really suit their personality and purse.

People requiring high lens powers enjoy an additional benefit from the system: in the past, they were barely able to see themselves properly wearing a new frame. This is now a thing of the past: whatever frames they like can now be inserted in their portrait – and they can then assess them exactly while wearing their current glasses.

The **LFA Pro** contains the entire collection of Carl Zeiss frames. However, this only provides a basis: the system can be extended by any frame catalog required. It only has to be digitized. This will be of particular benefit to firms with more than one outlet, as only one centrally maintained, virtual frame store is required for all points of sale.

The lens consultation process has also become much easier. The thickness and weight of different lens types can now be easily compared. Additional recording of the frame



shape is no longer necessary, as the frames are all already digitized.

On-screen assessment at home

Until now, however convenient and cost-saving these possibilities may be, anyone who wanted to show their nearest and dearest what they looked like wearing their new glasses had to do so directly on the eyecare professional's premises. There was no way of assessing the appearance of various frames on-screen at home.

This is precisely what has changed with the **LFA Pro**. It features a module which allows the required photos to be inserted in the internet. Using your own home PC, you can then not only access your own photo, but also combine it online with a wide range of frames. You can try them on for as long as you want – regardless of store opening times or the fatigue of an impatient salesperson.

Even the size proportions are no problem. To ensure that the right relation is obtained, the eyecare professional measures the distance between your pupils beforehand. The **LFA Pro** stores the photo and measured value in its software, and you can then try on any digitized frame virtually and with a perfect fit.

All at the click of a mouse

A detailed knowledge of computers is not required to try on the frames. The software menu is practically self-explanatory; after all, the procedure should be enjoyable, not wearisome. A new frame can be easily selected by mouse click, and the program places it automatically and with a perfect fit on the virtual nose. The resultant photo is so realistic that a mirror could barely provide a more natural image. Even a slight tint or lenses with an antireflective coating are no problem for the **LFA Pro**: here, once again, seeing what the eyeglasses look like with these features in everyday life is all just a mouse click away.

However, the availability of your photo on the internet does not mean that it can be accessed by everyone. A special code is required for this purpose, and this can only be obtained from your eyecare professional.

Up-to-date Web presence

The **LFA Pro** offers eyecare professionals another very special benefit: they automatically receive an up-to-the-minute Web presence – specially tailored to their own business and directly focused on clients' requirements. Eyecare professionals can now easily contact their clients: they can send them an e-mail, for example, to draw their attention to new digitized frames.

The module was developed in collaboration with the firm Dehler new media. It is a network solution in which special care has been taken to ensure not only compatibility of the interfaces with all common management systems, but also, of course, maximum ease of use.

Anyone selecting a new pair of glasses with the **LFA Pro** in future no longer needs to dread derisive comments. At most, someone may well complain that they were not invited to the selection evening in your living room.

Figs 2 to 6:
No matter what the location, the screen shows what frame with what lenses best suit the client's face.

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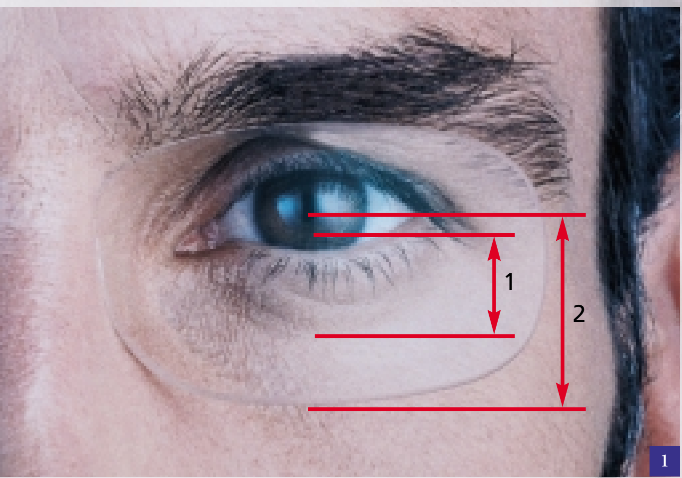
Personalized Lenses in Small Frames

For the first time in 2000, Carl Zeiss presented a progressive lens which is not computed or produced on the basis of the wearer's own personal parameters until after receipt of the lens order. Its name: Gradal Individual®. The resounding success and the numerous satisfied wearers prompted us to continue with the same approach.



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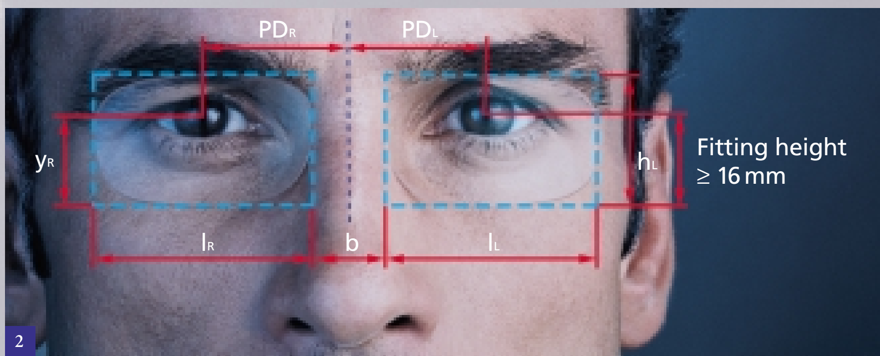
With **Gradal® Short *I***, the world's first progressive lens is now available that is individually produced for each and every wearer and additionally displays a very short transition between the distance and near zones. This makes **Gradal® Short *I*** ideal for small, fashionable frames.

Totally new progressive lens design

To implement this concept, a completely new progressive lens design with a shortened progression zone had to be developed. This was a total success. What is known as the minimum fitting height, i.e. the distance between the center of the pupil and the lower rim of the frame when the wearer is looking straight-ahead, measures only 16 mm. A comparison: In **Gradal Top® *E***, the standard progressive lens from Carl Zeiss, it is 22 mm long. The reading power is reached 20 % earlier and as much as 40 % earlier than in traditional progressive lenses. This makes **Gradal® Short *I*** with its perfectly positioned near zone the right choice for small, fashionable eyeglass frames.

No two wearers are alike

As in **Gradal Individual®**, the design of **Gradal® Short *I*** directly incorporates each wearer's own personal PD, back vertex distance, pantoscopic angle (the tilt of the frame), frame dimensions and near object distance. This results in ample ranges of vision despite the shortened progression zone. By taking into account each wearer's personal data and by optimizing the lens for each individual power, the restrictions which inevitably result from a shorter progression zone have been reduced to a minimum.



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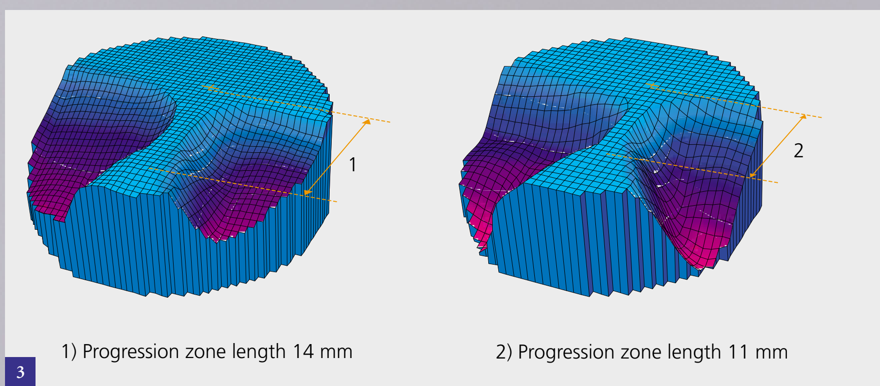

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Fig. 1:
With a progression zone of only 11 mm (1) and a fitting height of 16 mm (2), **Gradal® Short *I*** is the first progressive lens from Carl Zeiss for small, modern frames.

Fig. 2:
Thanks to the totally new progressive lens design with a short progression zone of only 11 mm, the recommended fitting height of **Gradal® Short *I*** is only 16 mm. All of the patient's personal parameters are taken into account.

Figs 3a and 3b:
3a: Gradal Individual®:
Large ranges of vision for each individual prescription and minimized aberrations in the peripheral zones are the hallmarks of **Gradal Individual®**.
3b: Gradal® Short *I*:
Despite its shortened progression zone, **Gradal® Short *I*** provides ample ranges of vision.

Oranna Guth, Ophthalmic Products Division
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Zeiss Lenses Were In On It, Too

More than 100 cine lenses from Carl Zeiss were among the tools of the movie makers who filmed the trilogy "Lord of the Rings", the first part of which was awarded four Oscars by the Academy of Motion Pictures in Hollywood in March 2002. One Oscar was presented for the best camera which resulted in the fantastic pictures shot with Zeiss lenses.

Fig. 1:
Fifteen **Ultra Prime** lenses form the most comprehensive set of fixed-focal-length cine lenses in the cine world

Only superlatives can suffice to describe this movie project that set new standards in quality and quantity of the equipment used: a budget of US $ 300 million, 1.3 million meters of footage, a film crew of 2,500, 20,000 walkers-on, over 1,200 computer tricks, about 1,600 pairs of artificial feet and ears, 7 film teams working together, 21 movie cameras – and more then 100 cine lenses from Carl Zeiss.

Special effects

By creating a film version of the successful novel by *J. R. R. Tolkien*, director *Peter Jackson* succeeded in completing a mammoth project in the history of cinematography after 15 months of shooting. The task was to bring to life a world of fantasy which until then had existed only in the minds of the readers of *Tolkien*'s novel.

The film was exclusively shot in the undescribable landscape of New Zealand – the ideal region for re-creating the lush meadows of the "Land of Willows", the "Black Land of Mordor", the steppes, forests, torrential rivers, mountains and the coast of "Middle-earth". The film is absolutely teeming with impressive images and special effects.

Ironsmiths, leather designers, embroidering specialists, tailors, shoemakers, jewelers, sculptors and many other experts were involved in reproducing the fantastic world of hobbits, elves, dwarves, wizards, men, orcs, ents, ringwraiths and Uruk-hais down to the very last detail. Each of the creatures and cultures has its own way of life, its own mannerisms, myths, ways to dress and fight.

These extremely professionally designed creatures can be experienced with all their eccentricities and idiosyncracies on the screen.

Lenses for professionals

This professionalism is also reflected in the camera and lens equipment used: ARRI Rental provided the cine cameras including a total of 112 cine lenses from Carl Zeiss. Thus, Carl Zeiss lenses clearly accounted for the largest number of the lenses used on location.

They included 8 sets of **Ultra Prime** lenses with 13 lenses each. A set now comprises 15 lenses and currently is the world's most comprehensive set of fixed-focal-length lenses with the high speed of f/1.7, providing superb definition and image quality.

In addition, three Carl Zeiss **Variable Prime** lenses were used, featuring the combination of a variable focal length, a high speed of f/2 and maximum optical performance. In 1999, Carl Zeiss was awarded a "scientific and engineering Oscar" for these **Variable Prime** lenses by the Academy of Motion Picture Arts and Sciences in Hollywood.

Five Carl Zeiss high-speed lenses with an initial aperture of f/1.2 (Carl Zeiss also received a "scientific and engineering Oscar" for these some time ago) rounded off the lens equipment which was worth a total of €870,000.

The result: a breathtaking cinema experience

Immerse yourself in the magic of the "Lord of the Rings" and relish a fantasy epic which is without parallel in the history of the motion picture arts.

Yvonne Maier, Camera Lens Division
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www.zeiss.de/photo

Fig. 2:
Scene from "Lord of the Rings: The Fellowship"
Source: Cinetext

100 Years of Carl Zeiss Tessar®

Exactly 100 years ago, Carl Zeiss was granted a patent for an invention which became the most famous camera lens of all times: the Tessar® lens.

Until the death of *Carl Zeiss*, the company's founder, in 1888, the firm almost exclusively manufactured microscopes with one exception: the Abbe refractometer. In the early days of the company's history, outstanding developments were made by *Ernst Abbe* who was first a scientific colleague, then a partner and finally the founder of the Carl Zeiss Foundation, thus increasingly determining the fortunes of the company. *Ernst Abbe* was not only a scientist, but also an entrepreneur. Currency crises occurring around 1893 negatively affected the export of microscopes which induced *Abbe* to think about extending the product line, thus reducing the company's dependence on only one product. From 1888, *Ernst Abbe* started to diversify the product line. Camera lenses became a new business division. However, *Ernst Abbe* also granted licenses to companies outside Zeiss. This procedure avoided an abrupt growth of the new division at the expense of the other divisions. He deliberately accepted the disclosure of development and manufacturing know-how to competitors.

Fig. 1:
Dr. Paul Rudolph
the inventor of the Tessar® lens

A few highly talented scientists which he had employed played a major role in making this strategy a success. *Paul Rudolph* was one of these scientists. He is the father of some camera lenses which are still produced to this very day. He created the Anastigmat camera lens which was produced from 1890 and renamed Protar® in 1900. *Paul Rudolph* designed two further lenses during this period, the Planar® lens – produced from 1896 – and the Tessar® lens which has been produced since 1902. The name Tessar gives a clear indication of the structure of the lens: "tessares", Greek for "four", indicates that the lens consists of four lens elements.

What is the outstanding feature of Tessar®? In the early days of photography, pictures were taken in black and white. Glass plates were the "image storage media" used by serious photographers. The light sensitivity of the emulsions used was so low that shutter speed was counted in minutes. The preferred lenses at this time were two-element systems with a low speed and rather modest image quality. A few high-speed lenses existed with an aperture of about f/3.5 which cost more than a saddle-horse, provided pictures smaller than a postcard, and whose definition was limited to the center of the image.

Paul Rudolph used new types of optical glass provided by the Jenaer Glaswerk Schott & Genossen: for example, glass types with finer grading of the refractive indices at a given color dispersion. The use of these types of glass made it possible to achieve excellent color correction, including the correction of astigmatism, spherical aberration and field curvature in the Planar® lens. However, the lenses were large and heavy. As anti-reflective technology was still unknown at this time, the pictures also lacked brilliance.

Paul Rudolph found an ingenious solution to solve some of the problems. The Tessar® lens belonging to the type of "Triplet lens" was created. The design using a dispersive element placed between two collective elements results in anastigmatic imaging. Instead of individual elements, it is also possible to use cemented components. In this case, the image-side component consists of a dispersive and a collective element. The lens with its initial aperture – "speed" – of f/6.3 was patented in 1902. The redesign performed by *Ernst Wandersleb* in 1904 resulted in the Tessar® f/4.5 lens which was available from 1907.

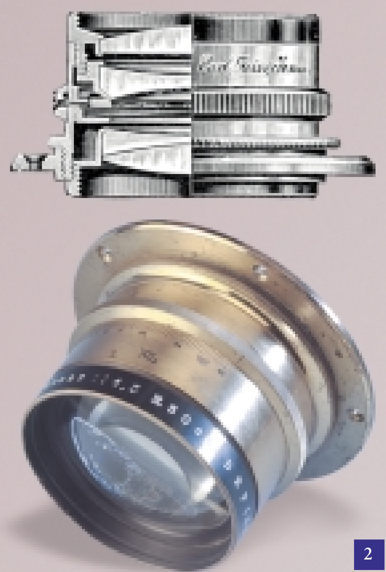

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Fig. 2:
Cutaway of a Tessar® and 30 cm Tessar f/4.5 lens for Ica 13 x 18 cm reflex camera

Fig. 3:
4.5 x 6 Sonnet with a 7.5 cm Tessar® f/6.3 lens
Contessa Nettel , Stuttgart, 1921

This was soon followed by an f/3.5 version for cinematography and projection. In 1908/1909, *Ernst Wandersleb* designed the precursor to the convertible lens sets of the Tessar® lens with an exchangeable front element. *Willy Merté*'s development resulted in the Tessar® f/2.8. lens in 1932. A year later, the Tele-Tessar®K lens (f/6.3/180 mm) with its sensationally high speed was introduced for the Contax® camera built from 1932.

A "quantum leap" in the image contrast provided by optical systems resulted from the "anti-reflective coating" invented by *Alexander Smakula* at Carl Zeiss, a thin, reflection-reducing, vacuum-deposited layer. A patent application for this procedure was filed in 1935.

The Tessar lens was launched on to the market in many versions. High-quality stereo lens pairs were part of the Carl Zeiss product spectrum at an early stage. For example, *Paul Franke* and *Reinhold Heidecke* used precisely paired 55 mm Tessar f/4.5 lenses in their first Heidoscop stereo camera as early as 1920, the year when they founded their company which was later to achieve world renown as "Rollei-Werke Franke & Heidecke". Worth mentioning is also the 500 mm I.R. – Tessar® f/5 lens for aerial photography in the 30 x 30 cm format. An interesting design created in 1951, the Zeiss-Ikon Panflex® mirror box, combined with the 115 mm Panflex-Tessar®f/3.5 lens launched in 1953, made it possible to use the Contax® viewfinder camera like a reflex camera.

Standard lenses like the current 45 mm Tessar® T* f/2.8 lens for the Contax reflex camera are generally achromats featuring correction of chromatic longitudinal aberration for two wavelengths. This also applies to the Tele-Tessar® lenses which became available for the 35 mm and the 6 x 6 cm formats from 1968. The modern lenses of the Tele-Tessar® T* type for the Contax® and Hasselblad Series 200 cameras are also achromats. The Tele-Tessar® HFT lens is available for the Rolleiflex System 6000. T* and HFT stand for enhanced transmission thanks to multilayer coating.

Higher demands made on color correction are met by apochromatic lenses which are corrected for three wavelengths. As early as 1923, the Apo-Tessar® lens was the most often used lens in reproduction photography. From 1982, a 500 mm Tele-Apotessar® f/8 lens was provided for the Hasselblad 550C camera. There are now different versions of the Tele-Apotessar® T* lens for cameras such as Contax®, Contax® 645 Autofocus from Yashica and cameras from Hasselblad and Rollei.

The image definition and brilliance provided by the Tessar® lens resulted in the slogan "the eagle eye of your camera" in 1931. The image-side cemented component was the original from which the "lens logo" was derived and used for many decades as a trademark of the company. To this day, Carl Zeiss has produced about 5 million Tessar® lenses for image sizes measuring from half a fingernail to the door of a room. All over the world, lenses are produced which are based on the Tessar® design, some licensed by Carl Zeiss. The result: more than 150 million units sold to this day.

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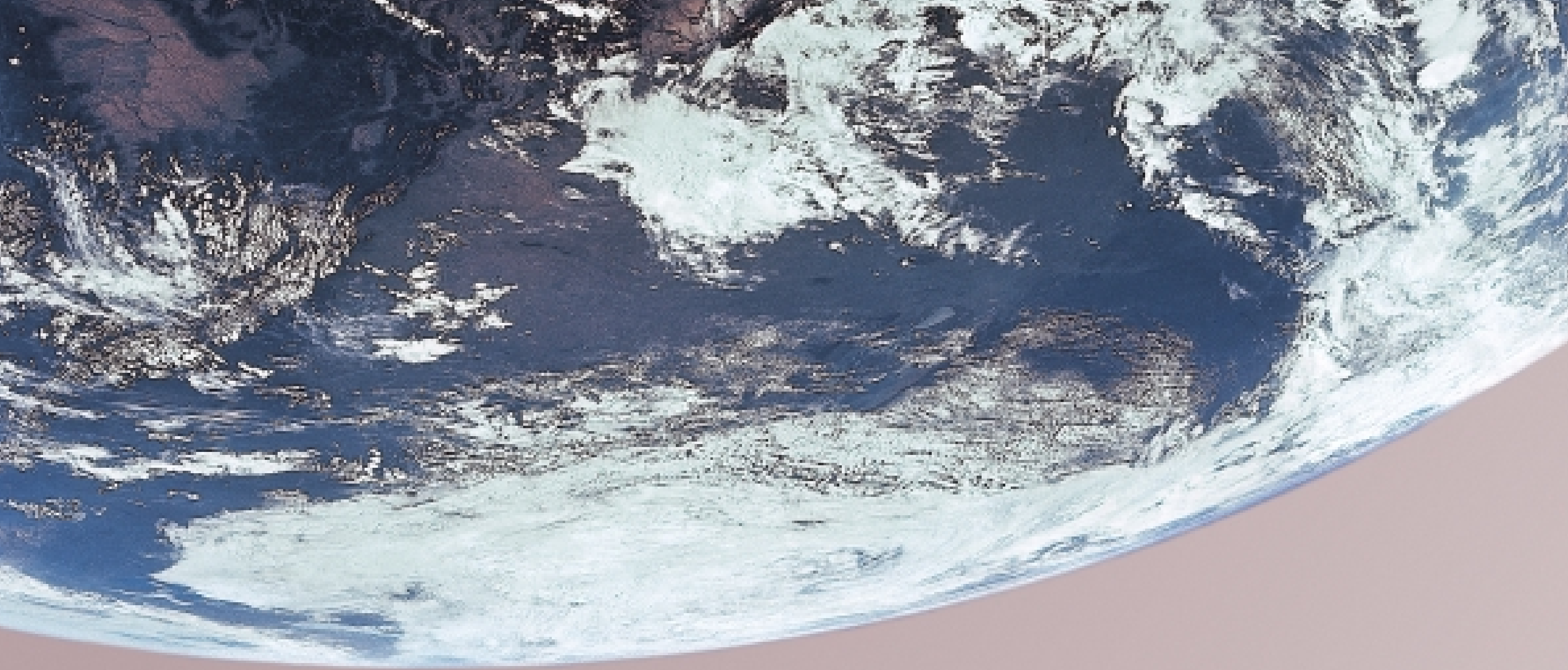
Note:
Tessar® is a registered trademark

Fig. 4:
Contax® Aria with a 45 mm Tessar f/2.8 lens

"Star of Vision Award"

Ahead of the biggest ophthalmic exhibition in the USA, the "Vision Expo East Award", pioneering achievements in the optical industry are awarded prizes. In 2002, the panel of specialists presented the Star of Vision Award to Carl Zeiss, for a trail-blazing invention made in 1935: the anti-reflective coating of optical surfaces developed by *Prof. Alexander Smakula*. Since then, the anti-reflective coating has also improved the results obtained with the Tessar lens as is illustrated by the two historic photos taken with and without AR coating. It is not unusual for pioneering inventions to remain in use for a long time, but it is certainly not an everyday occurrence for them to be honored with an award many decades after they have been made.



100 Years of Prontor

Today, we are all familiar with them: pictures of the earth taken from space. In the early 1960s, they were a real sensation: fascinating, genuine photos of the Blue Planet, taken with a Hasselblad camera and a Zeiss lens.

Initially, experts argued that any attempt to take photos from space would be useless, as the earth's atmosphere would make it impossible to recognize any detail. As the photos *John Glenn* took with his own 35 mm camera during his three orbits in the Mercury capsule around the globe in 1962 proved to be very useful, however, an almost feverish interest arose in professional photographic documentation from space. NASA considered building a "space camera", only to ultimately discover that such a camera already existed. A Hasselblad 500 C with a Zeiss 80 mm **Planar®** f/2.8 lens was purchased from a camera dealer in Houston. This camera was then slightly modified and given to *Walter Schirra* on the following space mission in October 1962. The results were really fascinating. In the subsequent years, thousands of space photos were taken during the Mercury, Gemini and Apollo missions using a Hasselblad camera with a Zeiss lens.

When people talk about Hasselblad and Zeiss, it is often overlooked that the perfect interplay of the two systems requires a third, no less important component right from the beginning: the between-lens shutter including the lens focusing mount for precise exposure control.

At the turn of the century, a growing group of photography enthusiasts already agreed that the exposure method used then – removing the cover from the lens, counting and reattaching the cover – was not the right way to expose film in fractions of a second. For this reason, *Alfred* and G*ustav Gauthier*, two brothers from Pforzheim/Germany and owners of a camera production plant in Paris set up a workshop in Calmbach in the northern Black Forest in 1902 for the development and manufacture of mechanical shutter systems.

The breakthrough came in 1904 with the new "KOILOS" shutter principle. They discontinued the production of cameras and from then on concentrated on the production of shutters. Acknowledging the importance of the precise interplay of functions between the lens, the shutter and the camera used, Carl Zeiss acquired a minority stake in the expanding company "Alfred Gauthier GmbH" in 1910. In 1931, the founder of the firm retired for age reasons.

Carl Zeiss acquired a majority stake in the company then operating under the name "Prontor-Werk Alfred Gauthier GmbH". With the Prontor and Compur plants, the Carl Zeiss Group owned two companies for the production of between-lens shutters. When, in the mid-1960s, the success of the 35 mm SLR reflex cameras triggered a basic change in the demand for mechanical shutter systems, the Compur plant in Munich was closed. The development and the production of the Compur shutters which were supplied on an exclusive basis for Hasselblad camera systems as early as 1957 were successfully continued by Prontor.

Whenever mechanical between-lens shutters of the highest quality are required for professional photography, Prontor is the product of choice even in the hundredth year after the company's foundation.

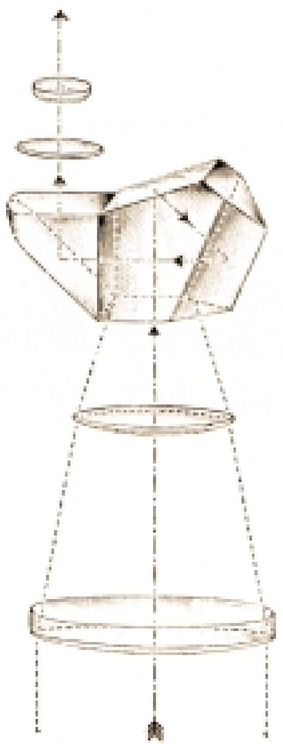
Photo above:
Photo of the earth taken from space, Apollo 11, 1969, using a Hasselbad camera with a Zeiss lens.

Photo below:
Focusing mount of CFE lens with databus contacts and integrated electronics for aperture simulation.

150 Years of Hensoldt

Who does not know the name "Dialyt®" – a byword for high-performance binoculars of the highest quality? However, who knows that the story of this legendary prism binocular began in Wetzlar, Germany, in 1905 and that this was the first binocular in which roof prisms were used to erect the upside-down, inverted image produced by the objective lens?

Hensoldt Dialyt system, 1905



This small town on the Lahn river in the heart of Germany where *Goethe* wrote the famous "Sorrows of Young Werther" during his law studies at the Imperial Supreme Court was the domicile of the "Optische Werke Moritz Hensoldt & Söhne". In 1865, *Moritz Hensoldt* moved his workshop from Sonneberg in Thuringia to Wetzlar. With its microscopes, binoculars and surveying instruments, the successfully growing company greatly contributed to the reputation of this region as the second most important center for the development and production of opto-mechanical top-quality products in Germany after Jena at the beginning of the 20th century.

In 1896, his sons *Waldemar* and *Carl* joined the company as partners. In addition to the manufacture of binoculars, riflescope production became a special field where the company excelled. In 1922, the company was listed as a stock corporation which was acquired by Carl Zeiss in 1928. Since 1964, Carl Zeiss has concentrated its binocular and riflescope production at Hensoldt AG in Wetzlar. In 1991, the new "Illumination Systems for Microchip Fabrication" business unit was set up. In the ten years since the founding of this unit, sales have risen from € 1 million to € 100 million.

In March 2002, Hensoldt AG celebrated its 150th anniversary. In the anniversary year, the company employs a workforce of approx. 800, making it one of the most important employers in the region. Three divisions currently form the pillars of business at Hensoldt AG: the Carl Zeiss Sports Optics Division (binoculars and riflescopes), Hensoldt System Technology (resulting from a merger of the military optics operations of Leica and Hensoldt) and the Illumination Systems for Microchip Fabrication. The company which is now a 100 % subsidiary of Carl Zeiss is currently recording sales totaling € 150 million and a positive operating result.

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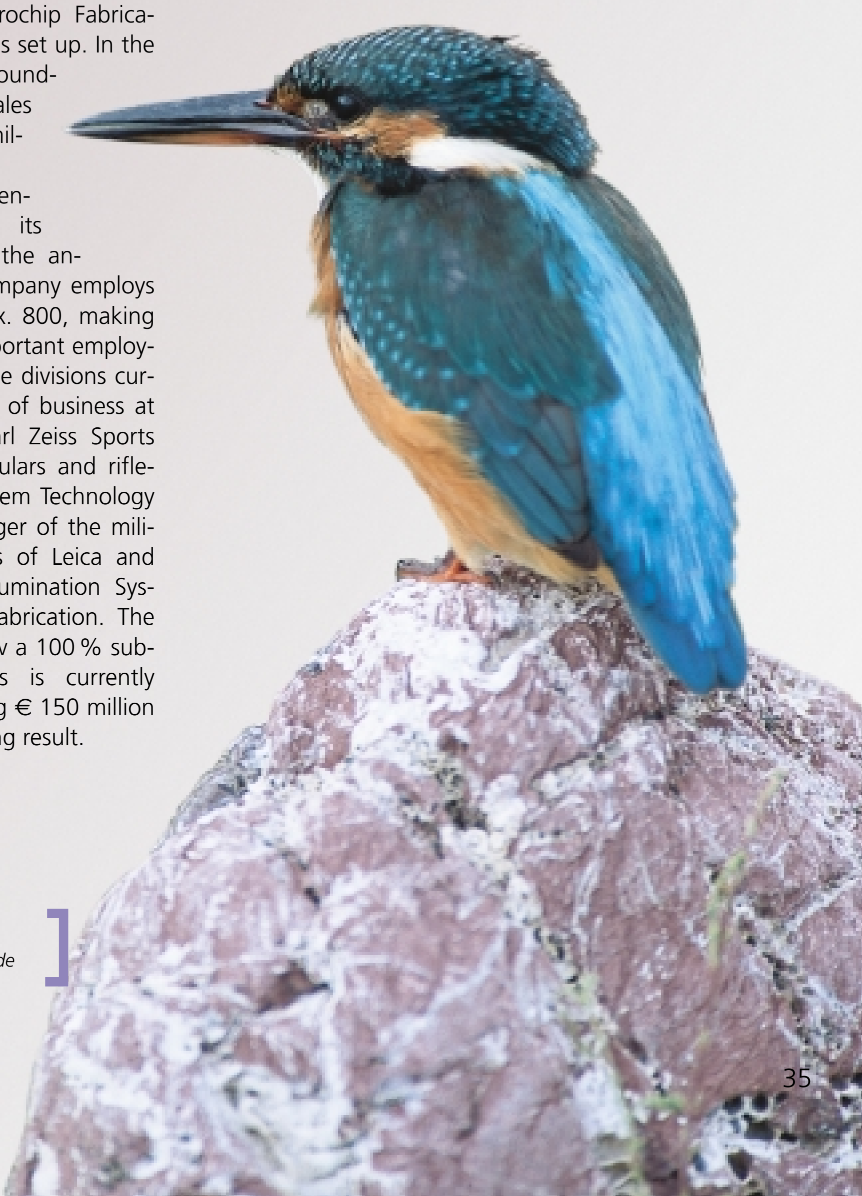
Figs 1 and 2:
Hensoldt's Dialyt system dating back to 1905 and today's version:
Victory 12 x 56 BT*



Innovations at the Service of Healthcare

In 2002, the Medical Systems Business Group of Carl Zeiss looks back on a 90-year history. On April 1, 1912, an independent "Medical-Optical Instruments" department was founded at Carl Zeiss. From this time on, there has been a vast upturn in business.

The success of medical technology has continued to this day. With sales totaling € 465 million, the business group achieved the highest sales figure at Carl Zeiss in the 2000/2001 fiscal year. The three divisions Surgical Products in Oberkochen, Ophthalmic Systems AG in Jena and Carl Zeiss Ophthalmic Systems, Inc. in Dublin (Ca.) employ a total workforce of about 1,500. The American company, one of the leading manufacturers of automated systems for ophthalmic diagnosis, joined Carl Zeiss in 1991.

Fig. 1:
Large *Gullstrand* Ophthalmoscope (1910)

The early days

The first product of Carl Zeiss optical medical technology was the "Binocular Corneal Microscope" developed by *Siegfried Czapski* as early as 1898. The ophthalmic examination instrument was based on a stereomicroscope developed by Carl Zeiss together with *S. Greenough*. After the turn of the century, a whole series of innovative and, for a long time, unrivaled diagnostic instruments was developed in close cooperation with the future Nobel laureate in medicine, *Allvar Gullstrand*. Their design is still prevalent to a certain degree in today's modern ophthalmic instruments. The "Large Ophthalmoscope" after *Gullstrand* (1910), for example, formed the basis for the *Nordensen* retinal camera (1925) and the present day fundus camera for documenting the fundus of the eye.

Always seeking new solutions

After World War II, surgical microscopes and photo coagulators from Carl Zeiss in Oberkochen went down in medical history. In 1953, the **OPMI® 1** surgical microscope laid the foundation stone for modern microsurgery. Specialists in the OR quickly recognized the benefits provided by a stable visual aid which is supported independently of the surgeon. In this way, surgical microscopes became the "eyes" of the surgeons. This heralded the beginning of yet another success story of Zeiss Medical Systems.

With the xenon photo coagulator introduced in 1957, light was used for the first time not for examination purposes, but for the direct treatment of the patient's eye – for Carl Zeiss its starting point for its entry into the medical laser system market in 1984.

The fact that the two Zeiss factories in the East and the West went their own separate ways after 1945 resulted in overlapping and parallel developments. The reunification of the two companies within the Carl Zeiss Group in 1991 made it possible to harmonize and refocus the product portfolio.

Leaders in surgical microscopes ...

Today, the Surgical Products Division is the market leader in surgical microscopes. Two out of three microsurgeons worldwide operate with surgical microscopes from Carl Zeiss. Innovative optical visualization technologies open up entirely new possibilities to all users in different specialist disciplines (from dentistry, ophthalmology and ENT to neurosurgery). With the **OPMI® Neuro MultiVision** surgical microscope, for example, digital image data is projected from the surgical field into the surgeon's eyepieces for the very first time. This additional information makes neurosurgical procedures safer for the patient. The **OPMI® Vario/NC 33** surgical microscope spearheaded minimally invasive, gentle spine surgery, a rapidly growing procedure. New developments in technologies of growing importance such as diagnosis during surgery and the use of micromanipulators ensure that Carl Zeiss can further sharpen its leading edge.

... and in ophthalmic diagnosis

The Ophthalmic Systems AG and Carl Zeiss Ophthalmic Systems, Inc. belong to the globally leading system providers for eyecare professionals. The product portfolio includes solutions for the diagnosis and therapy of all pathologies in the eye (glaucoma, ametropia, cataracts, retinal diseases). Here, the focus is also sharply on innovative products. The **IOLMaster®**, for example, sets new standards in the measurement of the eye prior to cataract surgery. It has been unrivaled since its launch in 1999. **VISULAS 690s** is the world's most frequently sold laser for photodynamic therapy of the eye, in other words for the therapy of age-related macula degeneration where an injected drug is activated by the laser. The Humphrey field analyzers of Carl Zeiss Ophthalmic Systems, Inc. represent the worldwide gold standard in the measurement and analysis of the visual field for diagnosing glaucoma.

Just recently, the Ophthalmic Instruments Division has initiated a first vital step toward complete diagnosis and treatment management of important pathologies by networking individual systems via special software. By combining the data obtained with different systems, additional diagnostic information will be obtained in the future.

The merging of the activities of Carl Zeiss and Asclepion-Meditec AG, Jena, in the ophthalmic field – a step announced in November 2001 – has given the future of Carl Zeiss Ophthalmology a clear orientation. It is planned to merge the Carl Zeiss Ophthalmic Systems AG with the publicly listed Asclepion-Meditec AG quoted on the stock exchange. Before the merger comes into effect, Carl Zeiss Ophthalmic Systems AG will also acquire the stocks of the Carl Zeiss Systems Inc. It is intended to establish Carl Zeiss Meditec AG as the world's leading provider of ophthalmic systems, with Carl Zeiss as principal shareholder.

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Fig. 2:
OPMI® Vario surgical microscope on **S 8** floor stand from Carl Zeiss for plastic and reconstructive surgery.

3

Fig. 3:
With the **OPMI® Vario/NC 33** System, Carl Zeiss has spearheaded minimally invasive spine surgery.

Technology focused on people

Always being ahead of our users' requirements, enabling new treatment methods, oriented on the benefit of the patient – this will continue to be the mission of Carl Zeiss Medical Systems.

Dr. Michael Kaschke, Member of the Board of Management and Executive Vice President and General Manager of the Medical Systems Business Group of Carl Zeiss: "People are at the very center of our activities. The high responsibility borne by every user when working with our developments makes us demand the utmost of ourselves and prompts us to continue our search for new, better solutions. To achieve this goal, we are aiming at an even more effective combination of past and future, of continuity and innovation."

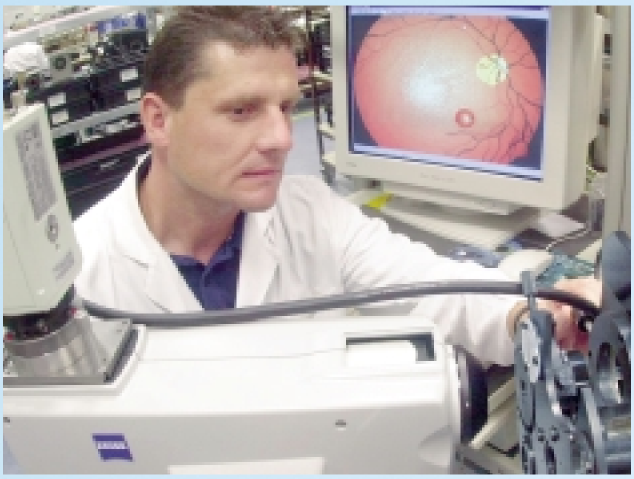

Fig. 4:
Assembly engineer *Jürgen Gehre* aligning a fundus camera, an instrument for retinal examinations. (Photo: *Jan-Peter Kasper*)

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2000/2001 Annual Report of the Carl Zeiss Stiftung

On more than 70 pages, the 2000/2001 annual report impressively testifies to the best consolidated result ever achieved in the history of the Carl Zeiss Stiftung.

In the 2000/2001 fiscal year the sales of the Carl Zeiss Stiftung – consisting of the Carl Zeiss and Schott Groups – rose to over €4 billion. The cash flow totaled €570 million. €401 million was invested in property, plant and equipment, a markedly higher figure than last year. R&D spending of €271 million on research and development is further enhancing the innovative strength of the two groups of companies. Despite the subdued forecasts for the global economy, slight growth is anticipated again in the 2001/2002 fiscal year.

The strategic alignment and organization of the Carl Zeiss Group into the four growth markets Semiconductor and Opto-Electronic Technology, Life Sciences and Health Care, Eye Care and Industrial Solutions has been confirmed as the right decision by the record sales figure of €2,056 million in the 2000/2001 fiscal year. All business activities within these growth markets are focused on six strong business groups with innovative, future-oriented products.

- Semiconductor Technology
  Lithography optics for wafer steppers and scanners, wafer and mask inspection systems, laser optics, electron beam technology for inspection and analysis
- Opto-Electronic Systems
  Optronics, camera lenses, optical components and opto-electronic modules, spectral sensors, planetariums
- Microscopy
  Light microscopy, advanced imaging microscopy with laser scanning microscopes, molecular medicine with UHTS systems
- Medical Systems
  Surgical products, diagnostic and therapy systems for ophthalmology
- Consumer Optics
  High-tech eyeglasses, systems technology, Sports Optics
- Industrial Measuring Technology
  Bridge-type measuring machines, measuring machines and devices for shopfloor use, industrial measuring services

Since October 1, 2001 the Schott Group has restructured its operations into five strategic business units.

- Home Tech
  Special glass for home appliances
- Display Solutions
  Glass for TV sets and computer monitors
- Advanced Optical Materials and Components
  Growing of calcium fluoride crystals, mask blank production, glass ceramics and glass for projection technologies
- Opto-Electronics
  Fiber optics and opto-electronic components for the automotive industry
- Pharmaceutical Systems
  Special glass tubing

The strong internationality of the companies in the two groups is clearly reflected in the numerous interests held in other companies across the globe. In September 2001 the global workforce totaled 34,006, including 14,220 in the Carl Zeiss Group and 19,786 in the Schott Group.

In his foreword to the annual report, the Commissioner of the Stiftung *Dr. Heinz Dürr* underlined that he would continue to promote the required future-oriented modernization initiatives together with the Boards of Management, the Advisory Boards, the employee representatives and the Stiftung administration. This modernization process will always be implemented in accordance with the basic ideas of the company founder *Ernst Abbe* and with Paragraph 118 of the corporate constitution written at the beginning of the firm's history: "if necessary, the constitution must be adapted to new technical and economic conditions". In future, as in the past fiscal year, the Commissioner will continue to meet his obligation "to involve himself verbally on site in the business management of the operating enterprises as far as possible" stipulated in Paragraph 18 of the constitution. He attaches major importance to acting not only as an individual person in the way envisaged by *Abbe*, but also in close cooperation with the Advisory Board at all times.

The annual report can be read at www.zeiss.de under the heading About Us.

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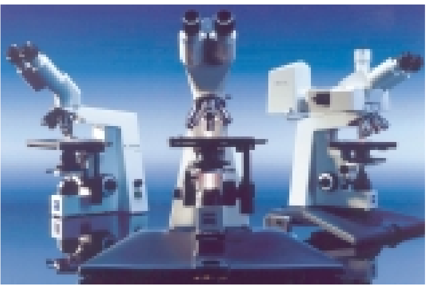
Light Microscopy

The **Axiostar®** entry-level microscope is now also available with high-quality fluorescence contrast and extensive ergonomic features – at a surprisingly low price! The **Axiostar® plus** is ideal for doctor's offices, hospitals, laboratories, schools and universities, and even for open-air use thanks to its optional LED illumination. The **Axiostar® plus**, a further development of the time-tested **Axiostar®**,



Axiostar® plus entry-level microscope

the smallest instrument in the Carl Zeiss line of upright microscopes, offers features previously only available in higher performance classes. This includes a fluorescence module for reflected-light illumination. A filter slider permits up to three fluorescence cubes to be used simultaneously thanks to the patented Push & Click technology. Fluorescence excitation is provided by the proven HBO 50 mercury lamp.

The **Axioskop® 40** and the fluorescence version **Axioskop® 40 FL** set new standards in routine microscopy. These microscopes combine optical and mechanical stability of the research class with the requirements of routine applications. This is achieved by a new ergonomic design, excellent user-friendliness and the availability of all the major contrasting techniques. The **Axioskop® 40** is ideal for laboratories in pathology, histology, cytology and hematology, and also for hospitals, foodstuff laboratories and

Axioskop® 40 routine microscope

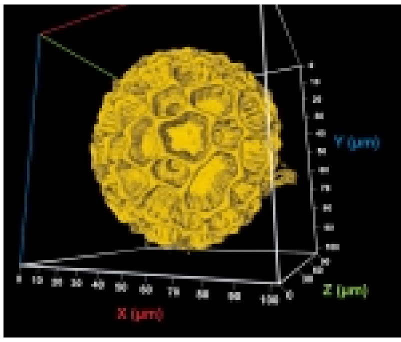
numerous applications in fluorescence microscopy, e.g. FISH (Fluorescence-In-situ-Hybridization) or immunofluorescence techniques. The 23-mm field of view, the optimized halogen illumination with a lamp life of more than 4,000 hours, and the fluorescence version's 5-position reflector wheel for Push & Click modules, the constant viewing angle of 20° and the possibility of continuous vertical adjustment by up to 50 mm are all features sharply focused on customer requirements. The flat front cap of the transmitted-light version ensures optimum specimen viewing from above. The instrument height does not need to be increased for the fluorescence version. The neutral-density filter rings are attached directly to the objectives – there is simply no easier way to change objectives for brightness adjustment!

The motorization of the **Axioskop® 2 mot plus** makes microscopic examinations in pathology, cytology, cell biology, developmental biology and genetic engineering even more easy, fast and efficient. While the Z-drive, permitting precise and highly reproducible operation, is always motorized, the choice between further manual, coded and motorized components permits the microscope to be exactly tailored to specific requirements. Thanks to this flexibility, the **Axioskop® 2 mot plus** is more versatile than any other microscope in its class. The consistent implementation of ergonomic requirements guarantees relaxed, fatigue-free microscopy. The **Axioskop® 2 mot plus** provides excellent imaging quality in all transmitted and reflected light techniques. This makes it ideal not only for morphologic examinations of stained and unstained specimens, but also for single and multifluorescence applications. When combined with

Motorized **Axioskop® 2 mot plus** microscope

the **AxioCam®** high-resolution digital camera, the **Axioskop® 2 mot plus** becomes a digital documentation system. The usual compatibility problems with components from different manufacturers are a thing of the past thanks to the system integration from Carl Zeiss.

The **AxioVision® Inside4D** microscopy software also enables scientists in biological and medical research to easily display correctly scaled fluorescence images in 3 dimensions – and even with the time dimension in the case of time-lapse recording – using traditional fluorescence microscopes. **AxioVision®** supplies everything from a single source, from correct image recording to image enhancement using 3D Deconvolution and the animated display of the object with **Inside4D**. The possibility of



Pollen grain in 3D: Z-stack fluorescence recording after 3D deconvolution, rendered in the surface mode of **AxioVision Inside4D**

easily setting and maintaining all the major parameters is an example of the high user-friendliness of the software. One of the extremely versatile applications is the possibility of viewing 3D structures with the time dimension. This opens up new insights into biological functions and interrelations. In combination with **AxioVision® 3D Deconvolution**, the **Cell Observer®** system or even the **Axioplan® 2FS** (observation of neuronal cells and tissues), excellent complete configurations are available for imaging in the life sciences.

The **FRET Analyzer 1.0** microscopy software enables highly variable FRET examinations. The tasks performed by cell and developmental biologists include the determination of the energy transfer amount of two adjacent protein molecules through Fluorescence Resonance Energy Transfer (FRET). Furthermore, it is important to know the distance between adjacent protein molecules which lies below the microscopic resolution. The **FRET Analyzer 1.0** software integrates various current methods for direct FRET measurements via acceptor bleaching. It is possible to record time-lapse series and FRET-dependent color-coded images. This enables users to select the method most suitable for their requirements and to determine the ideal time for the measurement without any need for experimentation. It is also possible to measure regions of interest, i. e. to measure directly in FRET images, and to record time-lapse series for FRET measurements. Until now, color-coded images of FRET specimens have only been available for one method.

The motorized **Axioplan® 2 imaging** or the **Axiovert® 200 M** is the ideal microscope platform for the **FRET-Analyzer 1.0**

Ophthalmology

The **VISUCAM** ***lite*** Digital Camera for the display and documentation of the fundus provides a variety of new possibilities. The observation without eyepieces makes all details of the 45° fundus image visible on the monitor during examination. The intuitive software allows easy operation and facilitates the ophthalmologist's routine work. The possibility of choosing from several capture modes creates optimum conditions for examination and documentation for laser therapy.

VISUCAM *lite* DigitalCamera

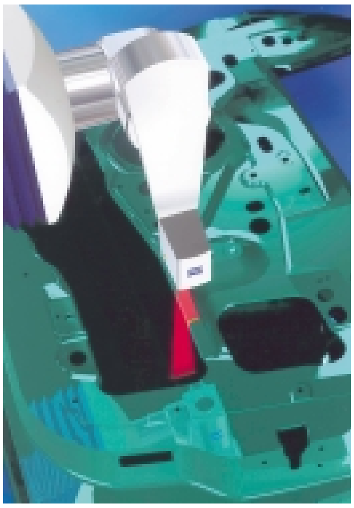
Surgical Products

Endoport™ is an integrated optical port for the attachment of all common endoscope cameras with quick-action locks for **OPMI® pico** without any annoying attachments at the top, the bottom, the rear or the side, and totally without any additional adapter. For this reason, the surgical microscope remains as compact with a connected endoscope camera as users expect a lightweight and rapidly movable diagnostic microscope to be. The endoscope camera can be attached in next to no time and is immediately ready for use. **Endoport™** can be retrofitted to **OPMI® pico** already supplied.

The **OPMI® pico** ***i*** diagnostic and surgical microscope is small and compact for use in ophthalmology. It features an innovative design with an optional, fully integrated video camera. The apochromatic 5-step magnification changer, the manual focusing objective lens and its small size make this unit the ideal basic microscope for ophthalmic examinations and surgery. The fully integrated video camera permits reliable case documentation without impairing the easy handling of **OPMI® pico** ***i***. The microscope can be used not only in the ophthalmologist's day-to-day work, e. g. for cataract surgery, examinations after laser refractive surgery (LASIK) and pediatric examinations, but also for the routine use on supine patients and in the emergency room.

OPMI® pico ***i*** diagnostic and surgical microscope for ophthalmology

The **EagleEye Navigator** for non-contact measurement closes the gap between in-line process control and the classical coordinate measuring machine in the metrology room. It swiftly provides high-accuracy results for controlling and analyzing the manufacturing process in car-body production. The six-axis sensor system aligns the laser triangulation sensor optimally with the measuring object and ensures instant readiness for operation. With its laser triangulation sensor, the **EagleEye Navigator** allows continuous scanning of 20,000 points per second. As large point clouds are analyzed automatically, and the features are identified and calculated in one step, the output of results is reduced to the essentials. This results in faster process analysis and process control.



EagleEye Navigator: measurement of edges and holes without the need for additional measurement preparation and post-processing work due to adapter handling

VAST® Navigator and its functional units

The **VAST® Navigator** offers enhanced measurement performance in shorter measuring times due to its all-encompassing concept consisting of sensor system, control technology, technique and software. On a cylinder bore, for example, the time saved may total as much as 30 % compared to conventional scanning methods. The tangential approach ensures an uninterrupted transition from travel route to probing process without any need for the stopping and reorientation required in conventional methods. The **VAST® Navigator** now allows even faster scanning. The basis of its technological infrastructure is a dynamic calibration process in which a stylus configuration has to be calibrated only once and can then be used for all scanning speeds on a wide variety of diameters.

The **SMC** is a horizontal-arm measuring machine which is the ideal answer to the requirements of modern process control in car-body production. Here, more than anywhere else, different sensors are repeatedly required due to the constantly changing measuring tasks. The multi-sensor system of the **SMC** automatically fetches the touch trigger and the optical sensors from the sensor magazine – and all in a simple calibration routine. The **SMC** also saves valuable time in the duplex mode. Thanks to its flexible installation concept, the floor-mounted CMM is perfectly suited for the production environment. If the production flow changes, the **SMC** can be taken in next to no time to the location where it is needed. All its components are protected so that dirt on the shop floor cannot harm the machine.

The **SMC** horizontal-arm measuring machine

Photographic and Cine Lenses

The sophisticated **DigiPrime® cine lenses** with focal lengths of 5 mm, 7 mm, 10 mm, 14 mm, 20 mm and 40 mm are truly top performers. Their optical design is practically diffraction-limited, i. e. free of aberrations, even at the very wide aperture of f/1.5. The resolution provided at the initial aperture of f/1.5 exceeds 400 line pairs per millimeter by far.

DigiPrime® cine lenses from Carl Zeiss – high-speed, practically diffraction-limited lenses for 2/3" HD cine cameras providing extremely high performance

With its field angle of 103°, the 12 mm **Distagon®** T* f/1.9 cine lens for the Super 35 format closes the gap between the 10 mm **Distagon®** T* f/2 lens and the 14 mm **Distagon®** T* f/1.7 lens (92°). The lens consists of 15 elements in 12 groups and achieves impressive optical quality. The resolving power exceeds 250 line pairs per millimeter. The chromatic difference of magnification has been particularly well corrected by the use of glass material with anomalous partial dispersion. Distortion has also been well corrected. "Breathing", the visible change in the field angle or the magnification during focusing, has been reduced to a practically unnoticeable level.

In reponse to requests from cameramen, the 180 mm **Sonnar®** T* f/1.8 lens from the line of **ULTRA PRIME** lenses with uniform color matching has been designed in such a way that it allows them to compress the third dimension and to use an extremely shallow depth of field in feature films and commercials. It is now possible to shoot scenes with superb quality in the Super 35 format. Several of the 9 elements in 7 groups have been made using special glass with anomalous partial dispersion. The lens provides outstanding optical quality with excellent correction of chromatic aberration. When the UP 180 is stopped down by 2 stops, its image quality is enhanced to an amazing level. Scattered light is minimized through the use of newly developed light absorption procedures and the **Carl Zeiss** T* multilayer coating. Distortion is also minimal.

Three new **CFE lenses** from Carl Zeiss for the Hasselblad 6 x 6 medium-format camera system

Hasselblad has launched three new CFE lenses for its 6 x 6 medium-format camera system: the 120 mm **Makro-Planar®** T* f/4 CFE, the 180 mm **Sonnar® T*** f/4 CFE and the Zeiss 250 mm **Superachromat®** f/5.6 CFE. **CFE lenses** for the Hasselblad system contain a fully mechanical all-metal between-lens shutter, aperture simulation electronics and data bus connections which are used by the bodies of the Hasselblad cameras with TTL metering for data interchange between the lens and the camera body. These camera bodies include the Hasselblad 202 FA, 203 FE and 205 FCC models. One field of application in particular will benefit from this: macrophotography. With the new 120 mm **Makro-Planar®** T* f/4 CFE lens, exposure compensation which may become necessary because of the long lens extension will be precisely measured by the TTL metering system of the camera and automatically taken into account.

The new 7-element 55 mm **Distagon® T*** f/3.5 lens is a moderate wide-angle lens for the medium-format **Contax®** 645 autofocus system which provides field angles similar to those obtained with the 35 mm focal length of **Contax®** 35 mm cameras. This compact and lightweight lens delivers excellent image quality across the entire image field, from the initial aperture to small f-stops. The lens can be stopped down to f/32, providing excellent depth of field. Distortion is kept within narrow limits, a particular strength of the retrofocus wide-angle lenses from Carl Zeiss. These qualities make the 55 mm **Distagon®** T* f/3.5 lens the ideal lens for press photography using the **Contax®** 645. Experienced photographers will use this lens for taking pictures of interiors.

The new 55 mm **Distagon® T f/3.5** lens is a compact, lightweight multipurpose wide-angle lens in the **Contax®** 645 system

Ophthalmic Products

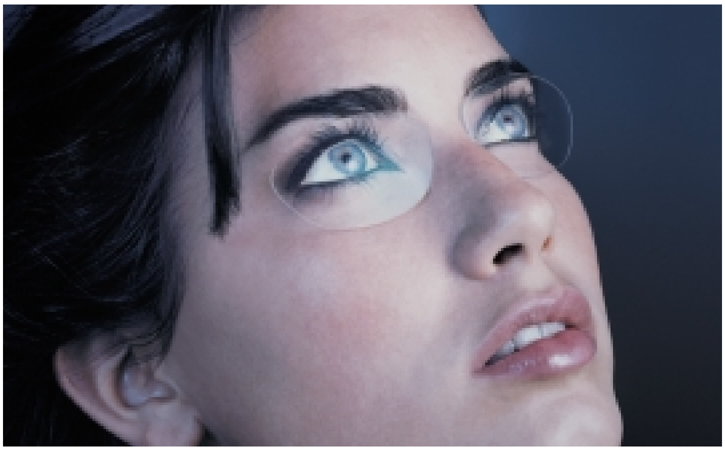
Clarlet® 1.74 AS is made of the plastic material with the highest refractive index currently available for eyeglass lenses. The index of 1.74 reduces the edge thickness of lenses for medium to high myopia by up to 40 %. **Clarlet® 1.74 AS** is always provided with a hard coating, a high-quality anti-reflective coating and Clean Coat. The power spectrum extends from -3 D to -10 D (cylinder 2 D). The Abbe number is 33 and the density lies at 1.47 g/cm³.

Clarlet® 1.74 AS: thinner and lighter for maximum wearing comfort

ProGolf is the name given to the contrast-enhancing sun protection lenses aimed at providing golfers with more enjoyment in the game. Compared to traditional, dark sunglasses, these lenses provide better visibility of any bumps or unevenness on the course, even in unfavorable light – the brightening effect also makes it possible to read the green without difficulty with changing light conditions during the round. **ProGolf** is produced in two versions: with a single color or a gradient tint, each with a standard **Carat® Super** coating package (hard coating, a broadband antireflective coating and Clean Coat). **ProGolf** is available as a plano, single vision or progressive lens on the basis of the proven **Clarlet®** plastic material with the refractive index 1.5.

One-Wire means extremely lightweight frames and sunglasses made of a single piece of titanium wire – without hinges, screws or soldering. This collection has three versions: four **One-Wire PUR** models in four eye shapes and different metallic colors embody the "purest form" of the one-wire approach: one piece of artistically formed titanium wire and a discreet nosepiece – that is all there is to it! The fit of **One-Wire COMFORT** can be optimally adjusted to the wearer's requirements. The nose pads required for this purpose sit inconspicuously on an elegant suspension – also made of titanium wire. **One-Wire SUN**, fitted with high-quality sun protection lenses, sets new standards in lightness, wearing comfort and functionality. Attractive eye shapes and fashionable lens colors are held in position by a single piece of ultra-light titanium wire.

One-Wire SUN:
Outstanding sun protection



Clarlet® Transitions:
Brighter, darker, faster

With its fast reaction times, high maximum absorption and light basic tint, the plastic lens **Clarlet® Transitions** meets all of the major demands made on photochromic lenses. In all three criteria it offers a level of performance never achieved before. In its clear state the transmission of the lens totals 90 %, making it practically as transparent as a "white" lens. The maximum absorption in the darkened state lies at 90 %, and even at high temperatures approx. 80 % absorption is attained. **Clarlet® Transitions** is also the fastest photochromic lens from Carl Zeiss: 70 % of the tint is achieved in just 30 seconds.

Masthead

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Glacier landscape near Chamonix: "Then and Now".

Painting:
Das Eismeer von Chamonix. (The Sea of Ice at Chamonix). This painting by the personal physician of the King of Saxony, natural scientist and painter *Carl Gustav Carus* (1789 Leipzig–1869 Dresden) dates back to the period 1825/27 (Georg Schäfer Museum, Schweinfurt, Germany).

Photo:
Mer de Glace Chamonix. This photo was taken in 1995 by *Jan A. Piotrowski*, INQUA Commission on Glaciation Boreas, Taylor & Francis AS.