The Magazine from Carl Zeiss

Innovation

ISSN 1431-8059

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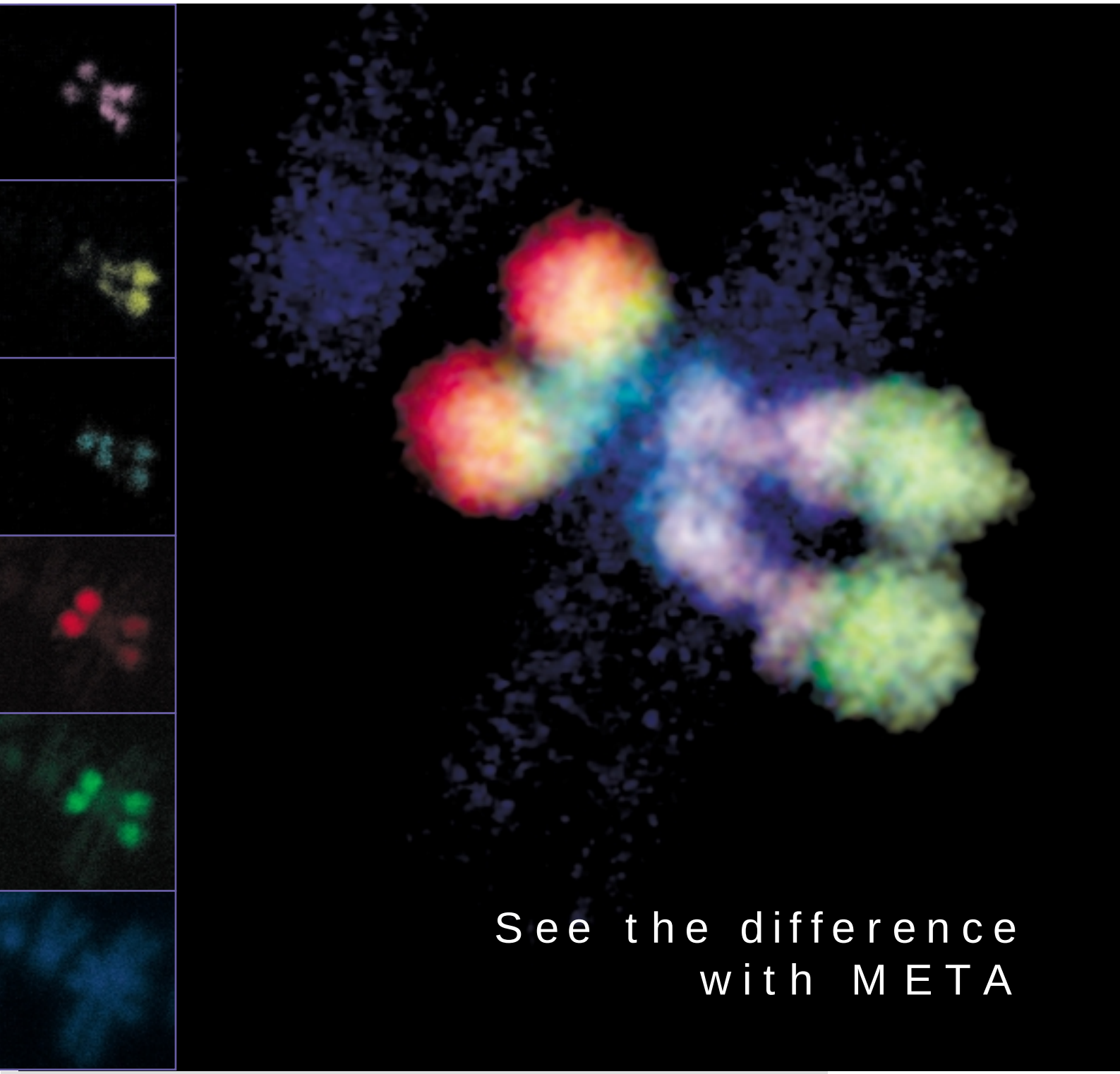

- Microscopy and Prion Research
- Minimally Invasive Surgery on the Spine
- Measuring Next to the Machine

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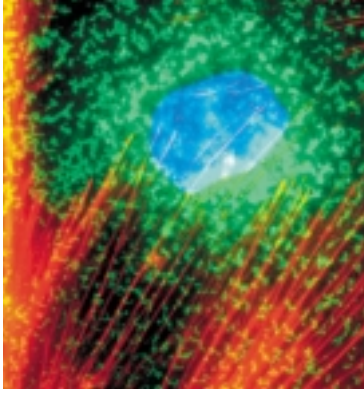

Developmental Biology and Cell Biology: Two Disciplines Unite

Prof. Kai Simons

In his classic textbook "The Cell in Development and Inheritance" published in 1896, *E. B. Wilson*, summarizing the years of biological research since *Schleiden* and *Schwann* formulated their cell theory in 1839, concluded that the key to all ultimate biological problems must "in the last analysis be sought in the cell". By analyzing a multitude of different organisms, the 19th century biologists had, at the turn of the century, already understood that the basic design of all living cells was similar. These startling insights were derived from careful observation of cellular behavior and structure using such simple tools as light microscopy combined with different staining methods. These discoveries set the scene for biological research in the 20th century and led to the biological revolution, which we are still witnessing today. Genetics played a key role in unraveling the molecular mechanisms responsible for inheritance and development. Genetic analysis was one of the few tools biologists had at their disposal to cut through the complexity of cellular processes and to identify the players involved. The final logic of genetic pathways became so powerful that the cellular context, i.e. where the gene products did their work, was almost blurred beyond focus. Typical of the success of the reductionist approach was that processes were often reduced to the effects of single genes.

"Developmental biologists and cell biologists have long ploughed their separate furrows. But now these two disciplines are coming together in unexpected and exciting ways."

Pearson, H. (2001): "Two become one", Nature. 2001 Sep 20.)

Today we know that several hundreds of genes are involved in controlling complex developmental processes such as limb development. Experimental strategies to unravel developmental mechanisms are therefore changing. Genetic screens are being complemented with novel assays that give insights into the cellular context where the proteins are localized and where they carry out their function. The cells in a tissue are no longer considered to be simple bags with nuclei. Developmental biologists are expanding their experimental tool kits with the kits of the molecular cell biologist.

During the last 30 years molecular cell biologists have been trying to understand the internal workings of a cell by focusing on a few model cell types, yeast and a small number of mammalian cells such as fibroblasts, epithelial cells and neuronal cells. This repertoire is now expanding, and it is becoming obvious that although the basic design of different cell types is very similar, the machinery responsible for cell and tissue organization is specifically modulated during embryonic development of the organism. A key to understanding the capabilities and the working mechanisms of the cellular machinery is to analyze changes which take place during cell differentiation. The cooperation of cell and developmental biologists is contributing to this as well.

Novel microscopic techniques have been transforming the field of cell biology and are now being increasingly used in developmental biology. Confocal microscopy led the way by giving a sharp three-dimensional view of cell architecture through the elimination of out-of-focus interference. Optical sectioning by image deconvolution is another way of obtaining images with high signal-to-noise ratios. The most recent newcomer is imaging by two-photon microscopy, which allows sectioning deep within a tissue and gives access to specimens that previously could not be imaged. The introduction of GFP, green fluorescent protein, has also sparked a revolution in cellular imaging. The use of these color markers has enabled cell and developmental biologists to use video microscopy to follow cellular dynamics. The combination of both epifluorescence and total internal reflection fluorescence microscopy has made it possible to trace the paths taken by proteins during transport from the Golgi complex to the cell surface with exquisite details of the kinetics. These methods are opening up fascinating vistas of cellular landscapes until recently not accessible to observation.

Our new Max Planck Institute of Molecular Cell Biology and Genetics in Dresden, Germany is an example of the marriage between cell and developmental biology. 20 research groups cover all the major animal models dominating developmental biology, Drosophila, C.elegans, zebrafish and mouse. The major goal of the research is to understand the molecular processes that cells use to form tissues.

The joint research has just begun and little is understood of how the cells' internal workings shape the development of an organism.

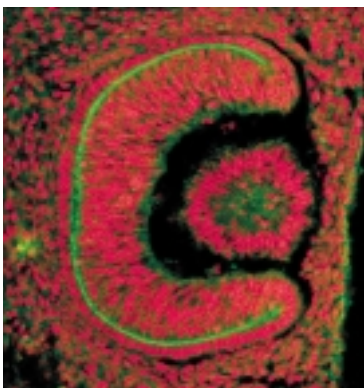

Fig. 1 (above): Fibroblast cell labeled in three colors: the cell nucleus (blue), actin stress fibers (red), lipid rafts (glycophosphatidyl inositol-anchored GFP, green) (Photo: Derek Toomre).

Fig. 2 (below): Eye of mouse, rod receptor cells (development stage). Plasma membrane protein Prominin (green), cell nuclei (red). (Photo: K. Röper, D. Corbeil).

Prof. Dr. Kai Simons, Director of the Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany.

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Cover photo:
Human chromosome 11 of intestinal cells (HT 29), dyed using multicolor banding. The LSM 510 META permits considerably more dyes to be simultaneously used for marking than was possible in the past, and their fluorescence emission to be allocated precisely in spite of spectral overlapping. META provides more information at a single glance, i.e. chromosomal irregularities can be detected and genetically related diseases can be diagnosed at an early stage. The improved structural resolution increases the reliability of diagnosis. Specimen: *Dr. Th. Liehr, Dr. V. Beensen*, Institute of Human Genetics and Anthropology at Friedrich Schiller University in Jena, Germany (E-mail: i8lith@mti-n.mti.uni-jena.de). Micrograph using the LSM 510 META: *Dr. P. Ullmann*, Carl Zeiss. (Please also see the article: Making Laser Scanning Microscopy More Colorful, pages 10 to 12).

Outside back cover:
Since October 2001, the world's largest and most precise ring laser has been sited deep under the earth at Wettzell in the Bavarian Forest mountains. Carl Zeiss was responsible for the manufacture of the large ring laser.
(Please also see the article: Always Knowing Precisely How Fast the Earth is Turning, pages 18 and 19).

Publisher's Imprint

Innovation
The Magazine from Carl Zeiss
No. 10, November 2001

"Innovation" appears at irregular internals in German and English. It was formerly called "Zeiss Information with Jena Review" (1992 to 1996), previously "Zeiss Information" (1953 to 1991) and "Jena Review" (1956 to 1991).The issues of the magazine will be serially numbered, regardless of the year in question, beginning with No. 1/1996.

Publisher: Carl Zeiss, Oberkochen, Corporate Communications, Marc Cyrus Vogel.
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Internet: http//www.zeiss.de

Layout: Corporate Design, Carl Zeiss, Oberkochen; Manfred Schindler Werbeagentur, D-73431 Aalen.
Setting: Typografie+Medien Werkstatt Hermann, D-73114 Schlat
Printed in Germany by C. Maurer, Druck und Verlag, D-73312 Geislingen a. d. Steige.

ISSN 1431-8059

If readers have any inquiries about how the magazine can be obtained or if they wish to change their address (the customer number should be indicated, if applicable), we would kindly ask them to contact the editor.

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Microscopy and Prion Research

He is one of the leading researchers of the human variant of mad cow disease, i. e. the Creutzfeldt-Jakob disease: Professor Adriano Aguzzi considerably helped the world with his discoveries in the fight against the pernicious disease. Of course, the technical equipment he uses to examine the pathogens, known as prions, also plays an important role.

"Innovation" talked with the renowned researcher in the Neuropathology Institute at Zurich University, Switzerland, of which he is the director.

How did mad cow disease evolve?

We do not know exactly. There are two basic theories: one says that meat and bone meal containing scrapie-infected sheep brains was fed to animals. The other theory assumes spontaneous mutations in cattle. However, the real cause will most likely never be found.

Mad cow disease now plays a considerably smaller role in the media than one year ago...

That's right. But for us, this discussion never played a major role anyway. We just continued doing our job.

...which mainly revolves around the new variant of the Creutzfeldt-Jakob disease. How does it differ from the conventional disease?

We assume that the new variant of the Creutzfeldt-Jakob disease in humans is identical to mad cow disease. The new variant mainly affects young people, often even teenagers. Furthermore, the course of the disease is slower in most cases. We reckon on one to two years, whereas the classical variant proceeds much faster.

How many humans are affected with the new variant of the Creutzfeldt-Jakob disease?

We assume approx. 120 at present.

How do you expect this number to develop?

That's hard to say. Of course, I hope the number will remain as low as possible.

Are there any marked differences in the dangerousness of the variants?

No. Both variants are lethal. Only one variant is probably caused by the transmission of BSE.

What actually is the morphologic difference between normal mad cow disease and the Creutzfeldt-Jakob disease?

There is, of course, quite a number of parameters. For example, the tissue patterns are very different, and there is markedly more plaque inside the tissue.

Was microscopy a major tool for the discovery of the morphologic structures?

It is most definitely very important. However, I would say that we applied all the technical tools which are useful for us. Microscopy is one of them, no matter whether it is light microscopy, confocal microscopy or electron microscopy.

A major part of your work now consists in detecting the pathogens known as prions. Will microscopy play a role here?

Certainly. Let us take the movement of prions, for example – here we do not yet have enough tools to be able to clarify this problem morphologically and functionally, although this is exactly what we will have to do in the end. For me, a dream would come true if I were able to see in the microscope how prions move, for example within the spleen or the nerve tissue. However, technology has not yet advanced enough for the equipment to be used in the required way. For example, the sensitivity of multiphoton techniques is still not good enough for our purposes.

Does this mean you consider light microscopy in no way outdated?

True. I would never say that microscopy is outdated. Instead, I would say: microscopy is not yet advanced far enough.

Does your dissatisfaction mean that the microscope does not enable you to resolve sufficient structures? Or does it mean that there are not enough markers for prions to be able to detect them with the light microscope?

I guess both are right. But certainly sensitivity is the bigger problem at present.

How did the microscope help you in the beginning? Purely on the histology/morphology basis or also with suitable markers?

About five or six years ago we performed many morphology examinations. This was very important. After this, we laid more emphasis on molecular biology. But it would be good to return to morphology in the end.

But then with living specimens? Does this mean: living sections?

Yes, certainly, though not only, but also.

The whole world is waiting for a reliable way of destroying the BSE pathogen to make sure that BSE-free foodstuff becomes available on the market. How can the BSE pathogen be destroyed? And in what time can this be implemented on a large scale?

Various possibilities already exist today. For example, the use of very high temperatures or various chemicals. However, there are other areas where we are unable to destroy the BSE pathogen.

"My dream: being able to see how prions move under the microscope"

Fig. 1:
Professor Dr. Adriano Aguzzi, Director of the Institute of Neuropathology at the University of Zurich and the National Swiss Reference Center for Prion Diseases and member of the Scientific BSE Advisory Committee of the British government and the EU Commission, in his laboratory using an Axioplan® 2 imaging research microscope with digital AxioCam®. (Photo: Jesper Dijohn).

For example?

Blood, for example. Here it is not possible at present to achieve decontamination. And I would rather not make any forecasts about when this will be possible.

After all, particular importance is attached to blood in the transmission of the new variant of the Creutzfeldt-Jakob disease.

That's right. The problem in the future will be focused more on transmission between humans than from cattle to humans.

Why?

Because all high-risk organs like the brain and spinal marrow have been removed from the human food chain by now. At the same time, however, many people carry the mad cow pathogen in their bodies. It is conceivable that it can be transmitted to other people by blood transfusions or by insufficiently sterilized instruments.

How long will it then take for the disease to break out?

About 15 to 20 years.

In animal experiments you found out that this period is almost exactly 200 days in mice. Can this period also be determined with similar precision for humans?

This is what we assume. For the time being, the exact incubation period is unfortunately not known. We are therefore unable to say when the disease will reach its climax in humans.

Let us assume an incubation period of 15 to 20 years: is this the period of time required by prions to reach the human brain?

Yes, that's right. It seems that the prion only develops its adverse affect in the brain.

How does this long period of time come about?

There are various stages which the prions must pass before they reach the brain. And it is most likely that they get held up along the way.

Will all measures be too late once the prions have reached the brain?

Yes, most likely. But, of course, this is of interest to us, too. After all, we want to understand how the damage to the brain occurs.

What do you envisage as a possible cure?

This is quite easy: We must prevent the prions from reaching the brain in the first place.

You once mentioned that about 100 million people had been in contact with the pathogen. What does this mean?

Let me say this much: it certainly does not mean that all these people have been infected. And the disease will not break out in all who have been infected. Here, many factors play a role, for example the genetic disposition which we know nothing at all about.

There are also other theories about the Creutzfeldt-Jakob disease. There are people who support the virus theory, and some researchers consider chemicals as major co-factors. What do you think of these theories?

It's always good to have different approaches, and to check these again and again. Therefore, I can only welcome the various hypotheses from various scientists. However, the prion theory still seems to be most likely.

Do you as a scientist still enjoy eating beef?

Certainly. After all, the meat itself was the minor problem. What worried us were the complete components contained in it, e.g. brain or separator meat. But this has fortunately been taken from the market by now.

Adriano Aguzzi, Neuropathology Institute of the University of Zurich, Switzerland.

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Thin Sections for Fascinating Colors

Jakob Zbären, Heinz Gundlach

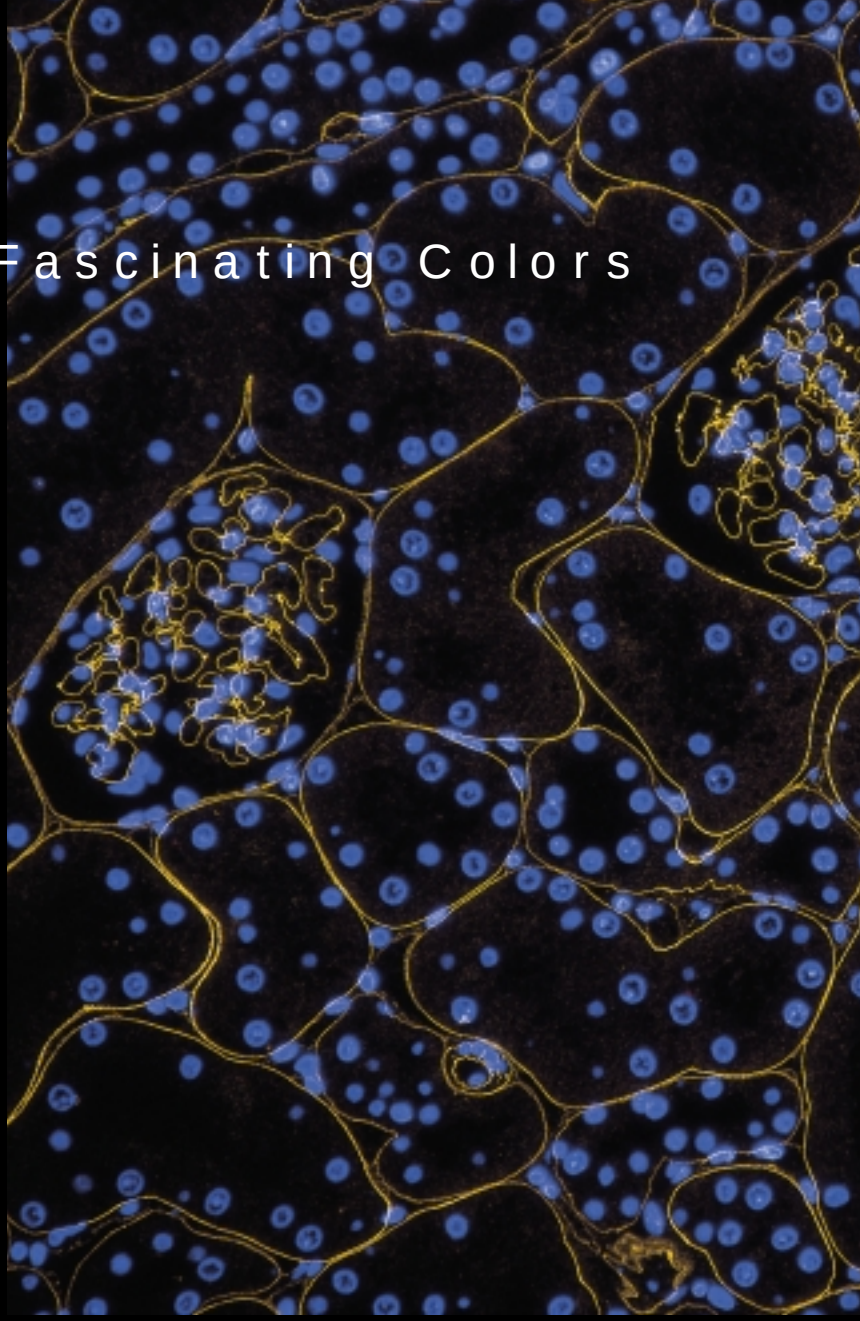


Fig. 1:
Kidneys of a rat, polymer section 0.75 µm, double marking with laminin (CY 3), filter FS 41007a, (10 s), cell nuclei (DAPI), filter 01 (16 s, gray filter).

Almost 100 years ago, August Köhler and Moritz von Rohr were able to observe fluorescence phenomena in a microscope with an ultraviolet illuminator for the first time. Today, fluorescence microscopy is a technique widely used in cell research, histology, genetics, and many other fields. Entirely new possibilities have become available to biomedical research thanks to the combination of fluorescence, confocal laser scanning microscopy, and high-performance digital image processing. Let us mention only a few key words: multicolor FISH, multicolor banding and – totally new – LSM 510 META, a system – introduced in this magazine – with a flexibility never achieved before.

Polymer and antibodies

However, further development has also taken place in traditional fluorescence microscopy. Here, progress in the past few years was achieved through multifluorescence techniques, the development of new dyes, the improvement of photomicrography techniques and the use of digital photography and image processing. Images of high information content and aesthetic beauty have become possible, not least because of new preparation techniques.

One of these techniques is polymer sections. Compared with the traditional embedding of specimens in paraffin, the use of polymer enables section thicknesses which are 10 times smaller, extending down to less than 1 µm. After immunohistochemical staining of these specimens, it is impossible for the large antibody molecules as carriers of the fluorescence dye to penetrate the polymer, i.e. the antibodies only bind to the surface of the section. State-of-the-art microscope systems such as the Axioplan® 2 Imaging or Axiovert® 200, and highly sensitive detection methods permit even higher resolution of object details (Figs 1 and 2) than has been possible so far. It is readily comparable to the resolution of low-magnification electron microscopy. But also the Axioskop® 2 inverted microscope allows such fluorescence to be viewed and documented (Figs 3 and 4).

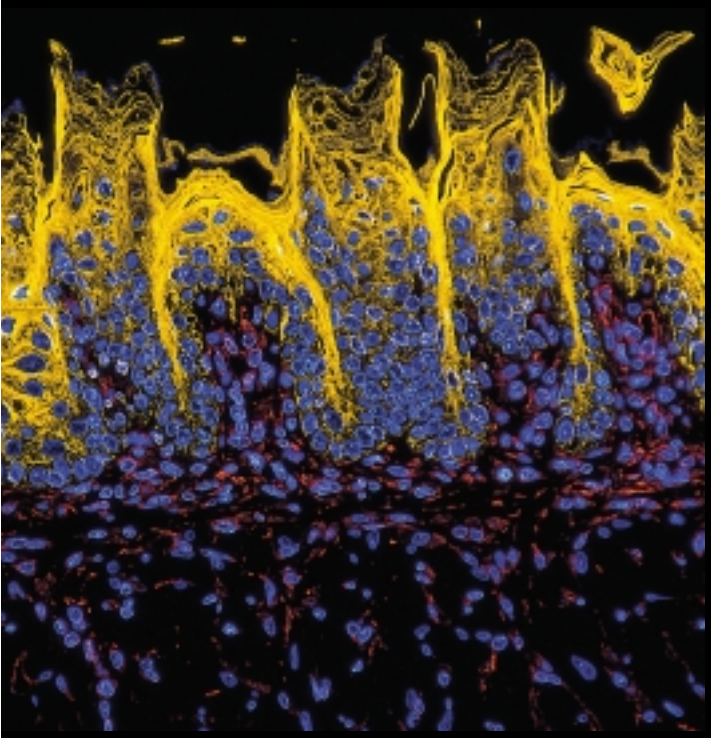
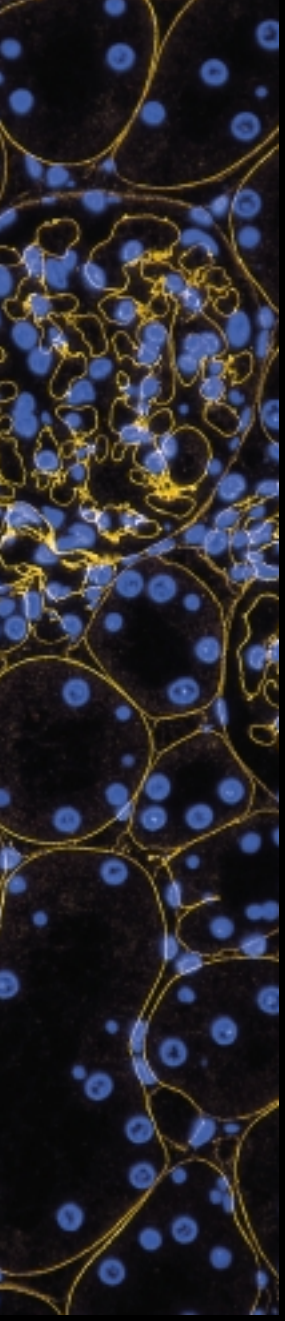
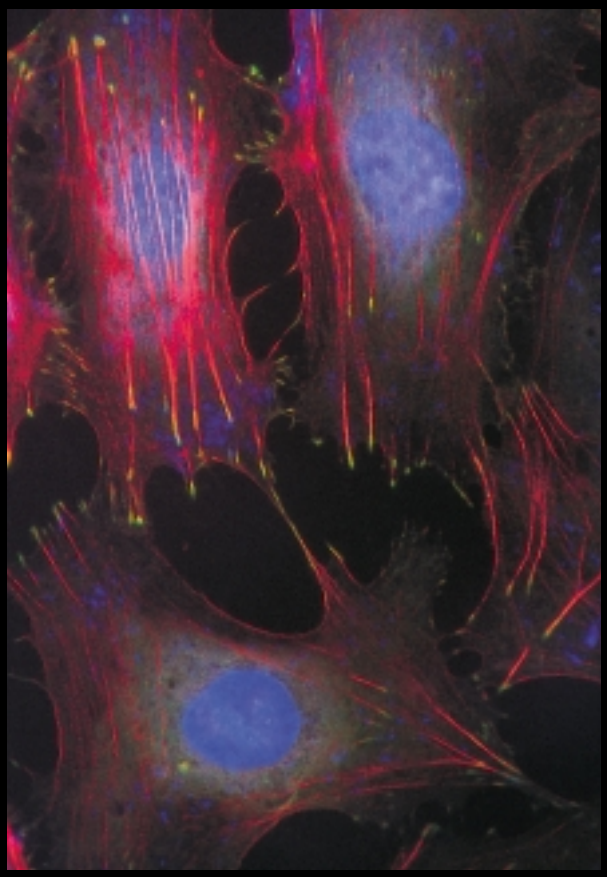


Fig. 2:
Tongue of a rat, polymer section 0.75 µm, triple marking with CY 3 cytokeratin, filter FS 41oo7a (exposure time: 15 s), vimentin (ALEXA 594), cell nuclei (DAPI). Filter 01 (10 s, gray filter).

From blue to red

New dyes, called fluorochromes with the family name ALEXA, cover the entire spectrum from blue to red and provide color brilliance never achieved before. The high-precision filter technology of double and triple bandpass filters permits the simultaneous display and analysis of two or three of the fluorescence fluorochromes with only a single filter set. In





combination with high-resolution color films, the traditional method, i.e. classical photomicrography, permits up to four fluorescence types to be displayed simultaneously with high contrast and excellent resolution (Figs 3 and 4).

The Cy 5, Cy 5.5 and Cy 7 cyanin fluorochromes have extended the application possibilities in the red and infrared range, although they can only be displayed and evaluated using digital methods.

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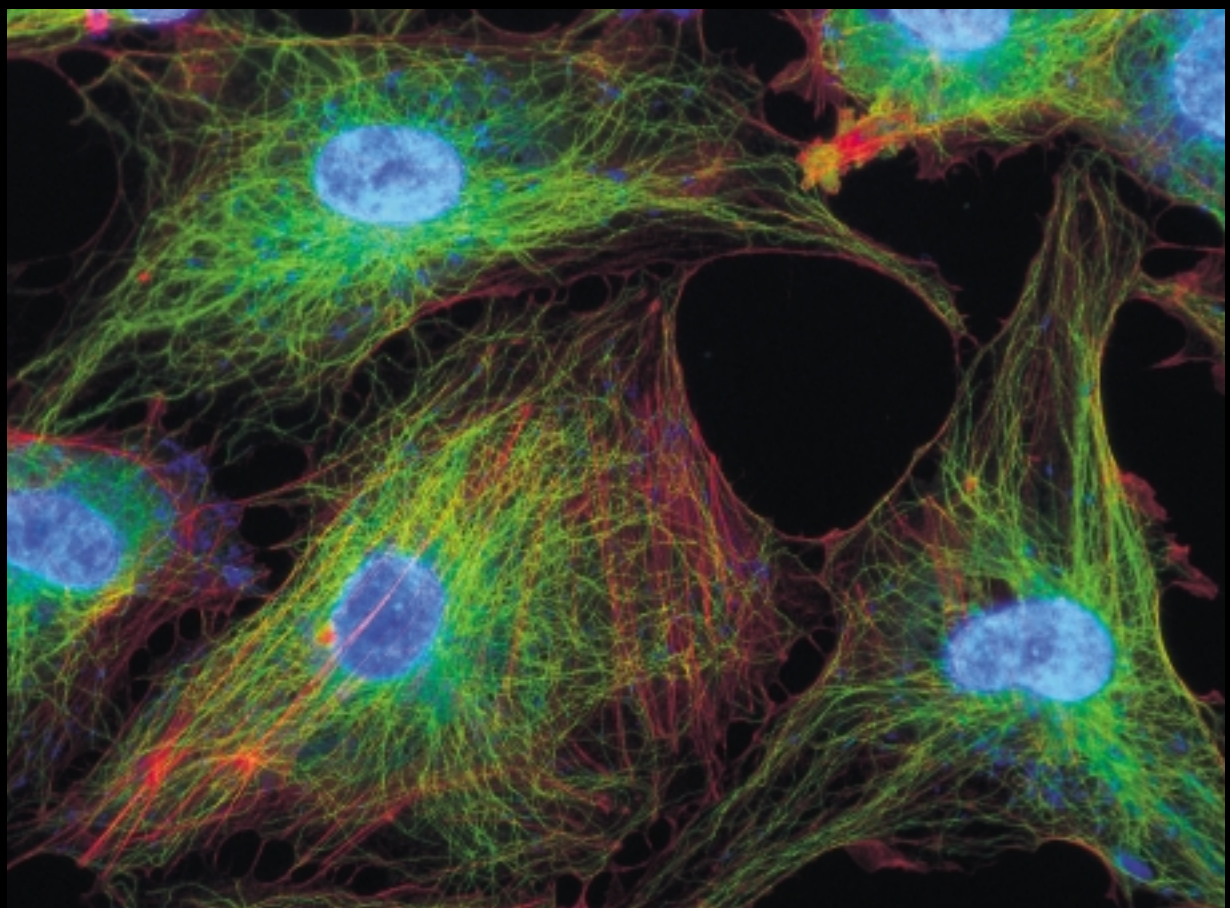
Figs 3 and 4:
Human endothelial cells.
Fig. 3: Quadruple marking with actin (phalloidin ALEXA 594), of Willebrand factor (ALEXA 350), vinculin (ALEXA 488) mixed fluorochrome, cell nucleus (DAPI). Filter 01 (24 s, gray filter), double bandpass filter 24 (28 s).
Fig. 4: Quadruple marking: actin (phalloidin/TRITC), of Willebrand factor (ALEXA 350), tubulin (ALEXA 488), cell nucleus (DAPI). Double bandpass filter 23 (45 s), filter 01 (15 s, gray filter).
(Micrographs: Jakob Zbären using the Axioplan® 2 Imaging, Plan-Apochromat 20/0.75, (Figs 1 and 2) and Axioskop® 2, Plan-NEOFLUAR® 63/1.25, (3 and 4), MC 80, double exposure. All photographs were taken with Fujichrome Velvia ISO 50 for professionals).



What Fossilic Cyanobacteria Tell Us About Primeval Oceans

Gernot Arp, Christian Böker

Fig. 1: Contemporary cyanobacterial lime reefs (stromatolites) near the bank of Lake Thetis, West Australia. (Photo: J. Reitner, Göttingen).

Dr. Gernot Arp

Dr. Christian Böker

Cyanobacteria (blue-green algae) have existed for at least 2.7 billion years and therefore number among the oldest organisms on earth. Like plants which came into existence later, they already used photosynthesis at that time, a process by which carbon dioxide is assimilated and oxygen released. As a result, cyanobacteria created an oxygen-rich atmosphere in the Precambrian age between 3.8 billion and 540 million years ago, without which the development of advanced forms of life in water and on land would never have been possible in the first place.

In the waterside areas of lakes and oceans, cyanobacteria and other microorganisms form what are known as biofilms which calcify in the appropriate conditions and can build meter-high, finely-layered reefs (Fig. 1). Enormous lime reefs, or stromatolites, were formed as far back as the Precambrian age and number among the earth's oldest fossils.

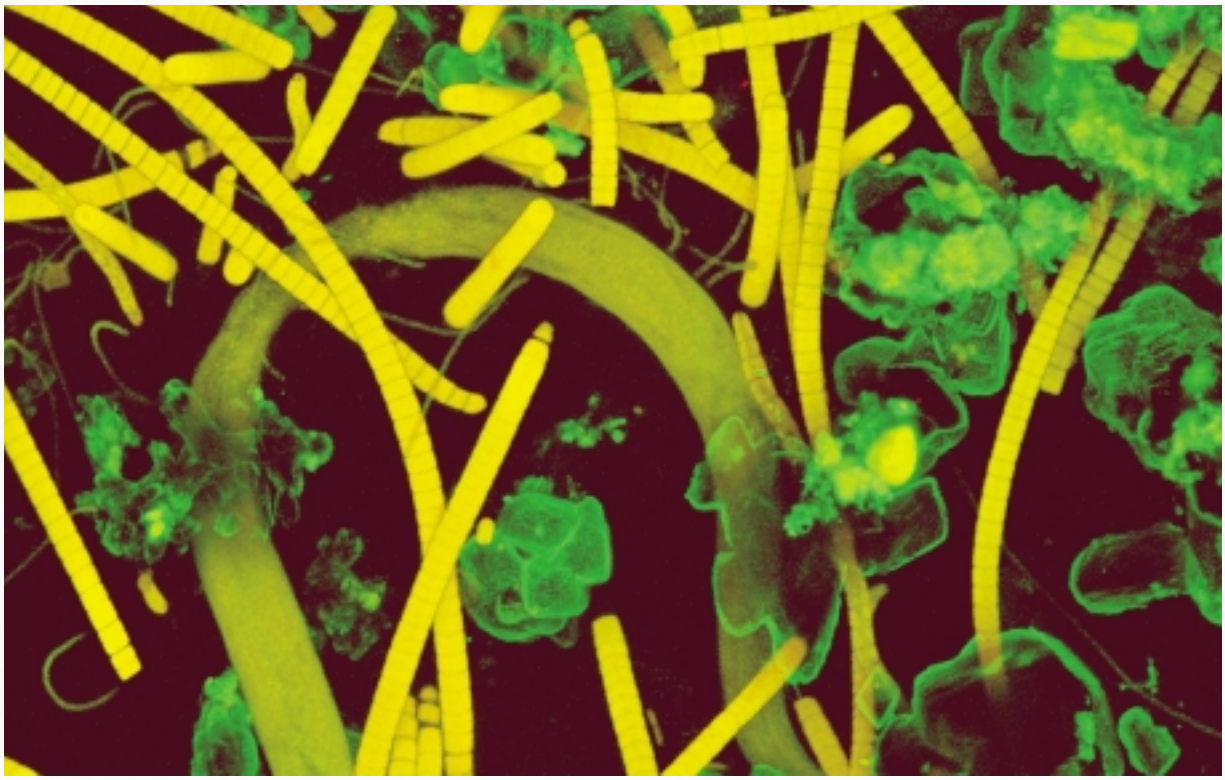


Fig. 2:
Biofilm with cyanobacteria (yellow, diameter: 5 µm), calcite crystals (green) and a nematode (green band) from a soda lake (Pyramid Lake, Nevada). The projection of 60 confocal image planes shows that the cyanobacteria are unable to precipitate calcium sheaths under the conditions prevailing in the lake, but that the calcite crystals are available in an unordered form in the biofilm. The micrograph was taken with an LSM 510 confocal laser scanning microscope from Carl Zeiss.

Until now, scientists believed that cyanobacteria would change the chemical equilibrium in their immediate surrounding by photosynthetic carbon dioxide assimilation in such a way that calcium carbonate is precipitated in their slime sheaths, thus causing a stromatolithic reef formation. But not all fossilic cyanobacteria in the lime reefs have a lime sheath. Photomicrographs of contemporary mineralizing cyanobacteria show that the lime crystals are mostly formed irregularly in the slime matrix of the biofilms (Fig. 2) and are bound directly to the cyanobacteria only in exceptional cases. The geobiologists *Gernot Arp*, *Andreas Reimer* and *Joachim Reitner* from the Göttingen Geosciences Center have now been able to unseal the mystery about such exceptions. Their model calculations show that the cyanobacterial photosynthesis results in lime precipitation only if high concentrations of calcium and low concentrations of inorganic carbon are dissolved in water simultaneously. Calcareous cyanobacteria fossils permit us to find out in which million-year periods this must have been the case. If the atmospheric carbon dioxide content of the air, which can be estimated for the geological ages by means of the stomatal density on Gingko leaves, for example, is taken into consideration, it is possible to calculate the minimum amount of calcium concentrations in primeval oceans for the first time. It then becomes evident that the calcium content fluctuated repeatedly between today's values and values which are up to three times higher.

Since calcium plays an important role in the metabolic processes of organisms, more detailed knowledge about changes in the calcium concentrations in the ocean could permit, for example, conclusions to be made about the evolution of crustaceans and the skeletons of vertebrates.

The renowned US "Science" magazine used the opportunity offered by the new insights into the calcium production of cyanobacteria to select a laser scanning micrograph of a biofilm with cyanobacteria as the cover photo of its 1 June 2001 issue and published the research findings of the Göttingen scientists in a special report.

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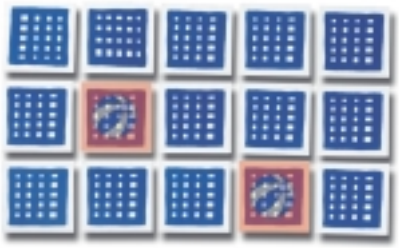
Making Laser Scanning Microscopy More Colorful

Sebastian Tille

You do not always succeed in making coffee the same way every time. And when it does taste really good, the chances are you won't remember how much coffee, water and milk you used – and whether you added one or two lumps of sugar. Wouldn't it be great if we could analyze the composition of the coffee at a single glance, without any need to take the successful mixture apart. In biomedical research, the question would be: what are the components of an intact cell, and how are they linked with each other? In addition to the structure, functional interrelations in living cells and organisms are also of interest, which leads to the second wish: being able to record active cells – like an entire day's vacation – in a single photo showing all details, even those which are not obvious at first. There is also a third wish, shared by children and parents when playing Memory: being able to always uncover the right combination of cards immediately – in other words, knowing instead of guessing! If we apply this to scientific experiments, this means: unambiguous and reliable results.



Experience the future today

We at Carl Zeiss certainly are no magicians either, but we use an entirely new approach to open up experimental possibilities for users of laser scanning microscopes (LSM) which were unthinkable until now. For the first time, the new LSM 510 META with its revolutionary Emission Fingerprinting technique permits the clean separation of several – even spectrally overlapping – fluorescence signals of a specimen. The number of dyes which can be used and detected in the experiment is almost unlimited. Thus, the new system overcomes the limits of existing detection methods and permits both qualitative and quantitative analyses, quickly and precisely, in vitro and in vivo.

GFP and the life sciences

Laser scanning microscopes are scientific tools mainly for use in the life sciences. They provide insights into cells and tissue. The fluorescence technique enables the visualization of cell components marked with various dyes and excited by laser light of different wavelengths. In the life sciences, the analysis of functional interrelations inside the cell is becoming increasingly important, in addition to the research of structures. Now that geneticists have completed the sequencing of the human genome, they are interested in the purpose of every single gene. Cell biologists not only want to know which proteins exist in a cell, but also what their functions are and with which other proteins they interrelate. Recording techniques such as FRET (Fluorescence Resonance Energy Transfer) or FRAP (Fluorescence Recovery After Photobleaching) allowing dynamic changes of the fluorescence emission to be followed are used very intensely for this purpose.

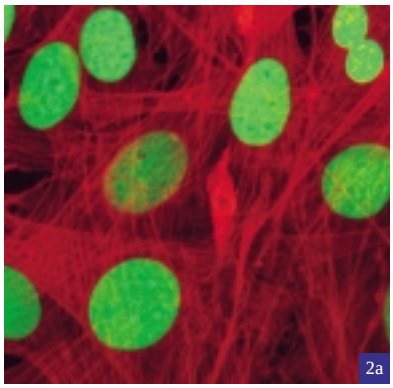
The discovery of natural fluorescence dyes, i.e. the green fluorescent protein (GFP) and its variants (Figs 3a and 3b), was a major step forward for multifluorescence microscopy. This non-toxic dye can be produced by the cells themselves, thus permitting the long-time observation of living objects.

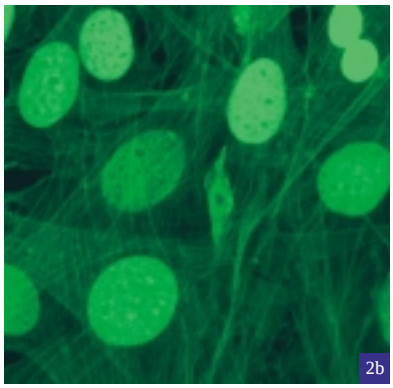
However, limits have been set here, too. The now improved "living dyes" display spectral properties which make their simultaneous use more difficult. The problem is known as signal overlapping, or "crosstalk". When several dyes are used, it is difficult, if not at all impossible, to find wavelength ranges where only one dye is guaranteed to emit, the signal of which can therefore be recorded using conventional bandpass detection. This problem could partly be solved using what is known as the multitracking technique provided by Zeiss LSM microscopes. However, no solution was available in cases where several dyes to be separated were ex-

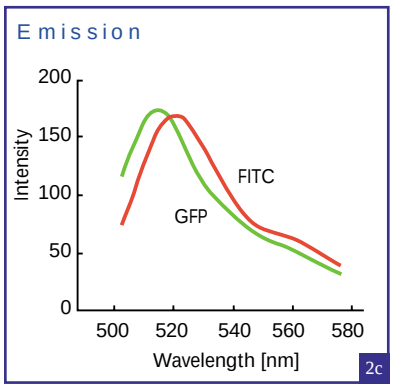
"This system provides a very easy way of performing FRAP experiments. I regret not having used this system earlier."

Prof. Yasushi Hiraoka,Kansai Advanced Research Center, Kobe, Japan.

Fig. 1:
LSM 510 META – a confocal laser scanning fluorescence microscope opening doors to new experiments.







Figs 2a to 2c:
Cultivated fibroblasts with expression of a GFP-Histon2B fusion protein, actin filaments marked with FITC phalloidin. Irradiation with 488 nm. Display via the new Emission Fingerprinting technique (2a) and by using the conventional bandpass filter between 505 and 530 nm (2b). Distance between emission maxima of GFP and FITC: 7 nm (2c).

cited for fluorescence by a single laser wavelength, since separation by means of bandpass detection is not possible in this case.

Emission Fingerprinting – the solution to the problem in multifluorescence applications

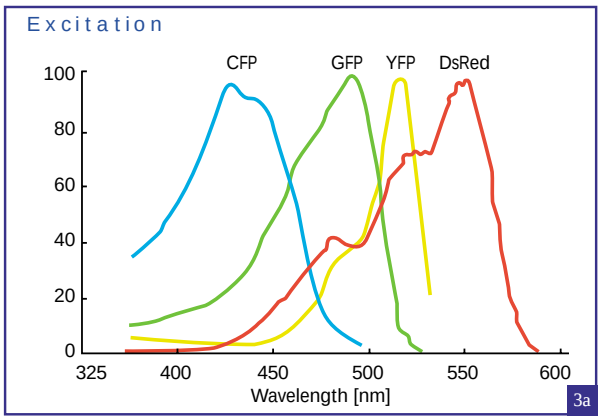
Due to our ongoing cooperation with users, these problems were known to us, as was the necessity to pave new ways for future applications.

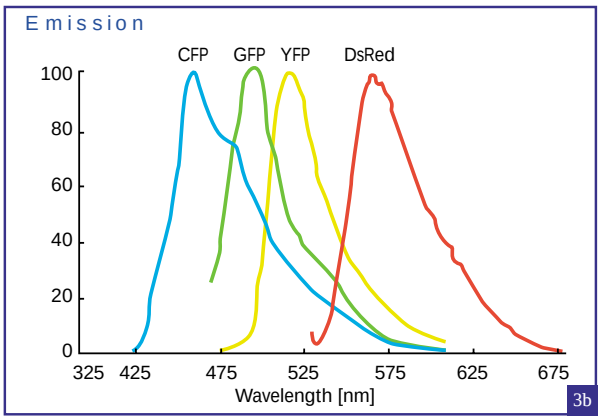
The Emission Fingerprinting technique is based on a new multichannel detector onto which the entire emission spectrum is projected and which can change these signals to digital information thanks to its fast electronics unit. The emission signals of the various dyes can now be separated in three easy steps:

1. Acquisition of a lambda stack, i.e. a stack of x-y images, to record the spectral distribution of fluorescence light as a parameter of each pixel in the examined object.
2. Determination of the spectral

"The new scan modes of the system offer a completely new quality of analysis. The interpretation of the data is far more reliable than with any conventional system based on filter sets and bandpass acquisition."

Dr. Frank-D. Böhmer, Molecular Cell Biology,
Friedrich Schiller University in Jena, Germany.





Figs 3a and 3b: Excitation and emission spectra of the GFP green fluorescent protein – of great importantance for the examination of living cells – and its variants CFP, YFP and DsRed, which – used simultaneously – could not be precisely separated with current techniques. (Source: Clontech).

signatures in selected specimen areas, or loading of reference spectra of the used dyes from the database.

3. Use of the Linear Unmixing algorithm, i.e. the digital separation of overlapping fluorescence signals in single image channels which only contain the intensities of one marker, clearly separated from each other.

The Emission Fingerprinting technique, entirely integrated into the LSM software, is easy to operate. It provides the unique possibility of separating fluorescence signals which were excited by only a single laser line, e.g. in multiphoton microscopy. Furthermore, it is beneficial in many cases for the elimination of unwanted signals, such as background noise or autofluorescence. The new technique of the LSM 510 META solves all these problems thanks to knowledge of the spectral properties of the specimen and the markers it contains – returning to our analogy with the Memory card game – this means that the right combination of cards is uncovered immediately without relying on luck. The recording of lambda stacks can be combined with 3D or/and time series (x, y, z, t, λ). Thanks to the electronic control of the multichannel detector, this can be done quickly and reproducibly. Combined with the information obtained about the entire emission spectrum, all events in the cells have thus been recorded – as would be the case in a single photo of a whole day's vacation. A wide spectrum of applications has already been tested successfully, and the users are enthusiastic about the method giving them a completely free hand in the selection and choice of fluorescence markers.

The LSM 510 META will help researchers to further increase the efficiency and success of their work. This gives them more time during which they can be inspired by the extended possibilities of the system and discover further secrets of biology in new experiments while drinking a nice cup of coffee.

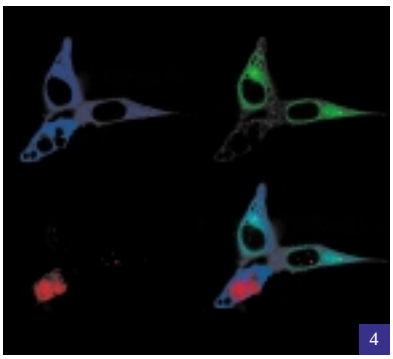


Fig. 4: Clear separation of CFP-RanGAP1 (blue, proteins in cell plasma), GFP emerin (green, proteins in cell membrane) and YFP-SUMO1 expression (red, cell nuclei) in cultivated cells. (Prof. Y. Hiraoka, KARC, Kobe, Japan).

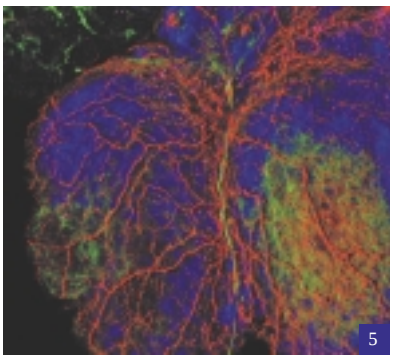


Fig. 5: Zebrafish embryo, eye and part of the brain; cell adhesion molecule tag-1 (Alexa Fluor 488, green), Tubulin (Cy3, red), sugar epitope PSA (Cy5, violet), cell nuclei (DAPI, blue). (Dr. M. Marx, Prof. M. Bastmeyer, Constance University, Germany).

"The LSM 510 META makes FRET imaging really easy because you get a spectral readout of both proteins. You see the contribution of both, acceptor and donor peak."

Mary Dickinson, PhD, Biological Imaging Center, Caltech, Pasadena, USA.

Sebastian Tille is Product Manager of Laser Scanning Microscopy at Carl Zeiss.

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Minimally Invasive Surgery on the Spine

A step forward or backward?

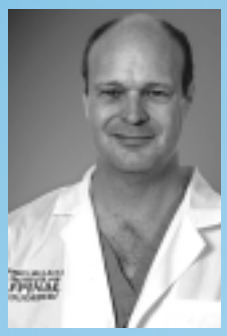
At the symposium entitled "Minimally Invasive Trends in the Spine Area" organized by Carl Zeiss during the 52nd Annual Convention of the German Society of Neurosurgery (DGN) in Bielefeld, Germany in May 2001, physicians and instrument manufacturers discussed the question: "Is endoscopy a step forward or backward for neurosurgery?" Although the participants in the symposium were impressed by the new possibilities available, some criticism was also voiced: "We now have wonderful, new technology at our fingertips, but the question remains – who can do what with what?" Some of the participating surgeons express their opinions below.

Fig. 1:
The OPMI® Vario/NC 33 system was developed exclusively for minimally invasive surgery in the spine area.

Technology of the Finest

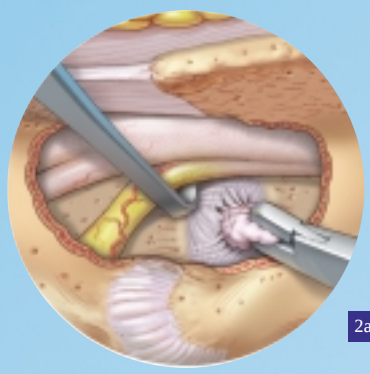
Robert S. Bray

In the operating room of the future, parallel, consecutive or alternating use will most certainly be made of minimally invasive techniques. This is already being practiced at the Cedars Sinai Hospital. The technical equipment ranges from state-of-the-art microscopes and navigation aids to 3D endoscopes and voice-controlled robots. The possibility of transmitting operations live via the internet already exists, archival is fully digital, and the technical equipment in the OR such as lamps and cameras can be voice-controlled. Two experts in the hospital have specialized in disk surgery and thoracoscopy. They offer workshops in which the participants can learn the techniques step by step. For example, an anterior lumbar fusion is possible through four incisions;

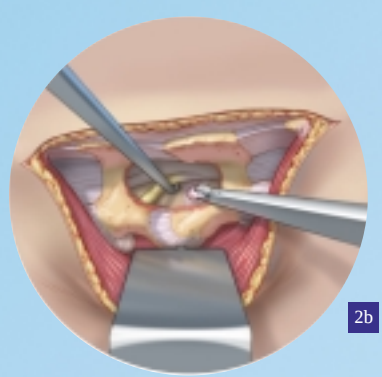


Robert S. Bray Jr., M.D., Institute for Spinal Disorders at the Cedars-Sinai Medical Center in Los Angeles. With more than 5500 microsurgical operations on the spine, he is a recognized specialist in this field.

Prof. Dr. med. Robert Schönmayr, Dr.-Horst-Schmidt-Kliniken GmbH, Hospital of the Provincial Capital Wiesbaden, Germany.



2a



2b

Figs 2a and 2b:
With its higher magnification and more powerful illumination, more anatomical details can be discerned in the surgical microscope (2a) than with loupes (2b).

Fig 3:
The ergonomic design of the surgical microscope allows the surgeon to work with the ultimate in comfort, even over long periods.

the patients are hospitalized for only two days, even if the stabilization was performed over several vertebrae. Hospital stays for anterior and posterior stabilization total only 1½ days in some individual cases.

Every spine, with the exception of those with severe scoliosis, can be a case for endosurgery. Thanks to the development of modern technology, the physician will also be able to work in areas where there is no room for their hands. The major advantage of robots will be that they do not get tired. One example: via an incision measuring only 3 cm, new artificial intervertebral disks have already been successfully implanted in six patients. At the Cedars Sinai Hospital traditional surgery is also performed in addition to these procedures using sophisticated, high-tech equipment.

Quo Vadis?

Prof. Dr. Robert Schönmayr

It is not a matter of endoscope versus microscope: what we want is a combination of the two technologies. However, as I see it, the transition to the endoscope is a step backward. For surgeons like us who are accustomed to using a surgical microscope, it is a major drawback that the three-dimensionality is missing. The miniaturization of open surgery and the extension of percutaneous techniques have good prospects for the future. For the patient, it is of great psychological importance to have only a small incision; the more minimally invasive the procedure, the better. In the USA hospital stays after surgery are considerably shorter than, for example, in Germany due to the greater use of keyhole surgery. Further improvements should be made to navigation aids, robotics, and miniaturization. The mobility of the instruments must be enhanced and their space requirements in the OR reduced.

What does "Minimally Invasive" Mean?

Dr. Wolfgang Börm
Senior Physician at the Bezirkskrankenhaus Günzburg, Neurosurgery, Germany

Minimally invasive – this is a very woolly term. Strictly speaking, only the incision is minimal; a lot of things also happen under it in minimally invasive procedures. For the success of the healing process it is not the length of the surface incision that is important, but the traumatization of the tissue under it. On the basis of the experience we have gained to date, we shall not use purely endoscopic techniques in future either. We prefer to operate with the visual control of the microscope. This is not as good in the two-dimensional endoscope image, and the aorta is very close.

Preparation Under the Microscope

Dr. Hans-J. Meisel
Berufsgenossenschaftliche Kliniken, Bergmannstrost, Neurosurgery, Halle, Germany

'Biological repair' must be our top priority. What we have to do is prepare osseous components in such a way that bones can heal again and no layers of degenerated cartilage remain in the fusion zone. For this purpose, a technique must be used which allows surgery via as small an incision as possible either by open microsurgery using the microscope or with the aid of an endoscope in order to minimize traumatization and muscle destruction. In this way, decompression can be achieved in the area of the spinal canal and the measures required for stabilization imple-

mented. This allows minimization of what was seen as major surgery in the past.

Today's standard of care

More and more people are now experiencing back problems at an earlier and earlier age. This is attributable to the increase in the number of sedentary jobs and to the fact that too much leisure time is spent sitting in the car or in the armchair. Nowadays, most of us have to cope with increasing stress and less exercise. Overweight in a rising percentage of people in the Western world and increased life expectancy are further contributory factors. These are all reasons why the number of spinal procedures is expected to rise in future. According to information received from leading neurosurgeons, these procedures will jump by as much as 40% in the next 5 to 7 years. From surgeons, patients are expecting a higher quality of care with less pain, and hospital administrators are under increasing pressure to reduce patient stays. The medical world is rising to this challenge by the use of minimally invasive methods. Surgical microscopes are the ideal visualization tool for this purpose.

Focus on results

The importance of minimally invasive surgery on the spine is undisputed: it reduces patient strain and shortens recovery times. The use of microsurgical techniques reduced hospitalization from 4.6 to 1.4 days and costs by more than 50% (Quality Study of the Cedars Sinai Medical Center).

The OPMI® Vario/NC 33 system was specially developed to meet the needs of the spine market. The symmetrical configuration of the system and its outstanding ease of use make it the ideal partner for the spine surgeon. Brilliant, apochromatic optics, incredibly simple user guidance, flexible positioning and the impressive daylight quality illumination are all brought together in a very compact, stylish design.

Carl Zeiss' visualization solutions have enabled surgeons to develop innovative, minimally invasive techniques that have improved patient outcomes and quality of life.

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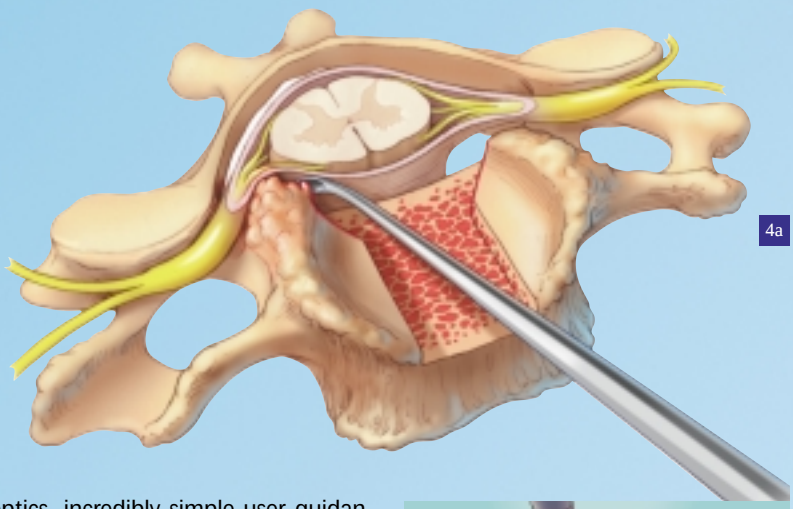
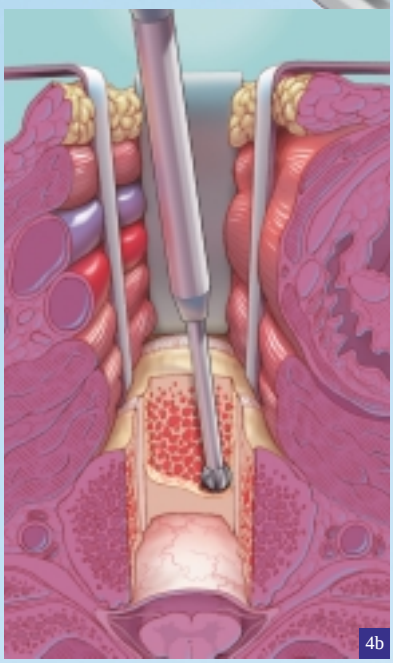




Figs 4a and 4b:
Ventral removal of cervical disks (schematic).

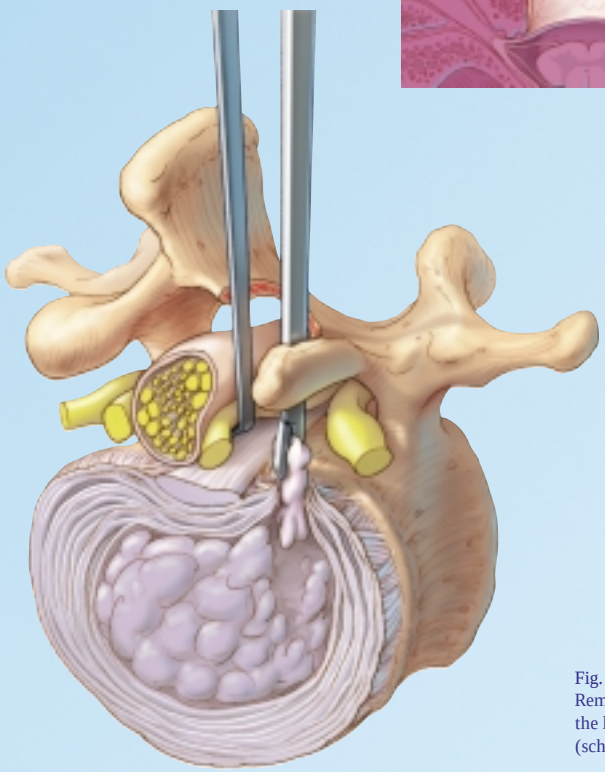


Fig. 5:
Removal of disk residue on the lumbar spine (schematic).

Too Hot to Handle

Fig. 1:
During production the glass bottles pass by the on-line hot end inspection system with the telecentric measuring lenses. (Photo: ART-KON-TOR, Jena).

During the production process bottles with defects are automatically removed. To date, however, this has not been done until the end of the production process prior to the packaging of the bottles and therefore a long time after the defect has actually occurred. Severe losses are the result, several 10,000 bottles leave the conveyor belt in the period before packaging. Now, with a "hot end" inspection instrument developed by the firm OTTO GmbH, Jena, Germany, the red-hot glass containers can be inspected immediately after production. The centerpiece of this measuring technology is telecentric lenses from Carl Zeiss.

The online inspection of the glass containers directly after production offers considerable advantages over traditional "cold end" inspection: the bottles are measured and sorted just a few seconds after manufacture. In addition, the hot end inspection system clearly allocates recognized errors to the manufacturing tools, allowing the causes to be quickly eliminated. The temperature of the hot bottle provides additional information on parameters relevant to the process. Therefore, hot end testing serves not only for quality sorting, but also for quality production.

A real hotshot system

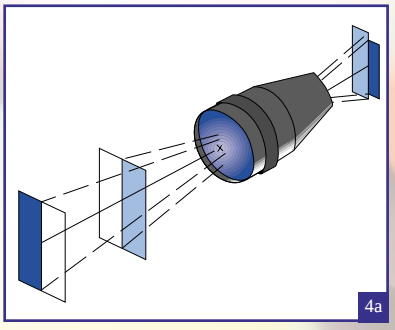
However, inspection at the hot end of container glass production has to contend with extreme conditions: the containers cannot be subjected to any handling during their journey from the machine to the cooling line. This means they cannot be specially

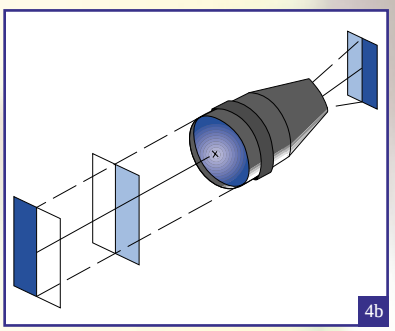
2

Fig. 2:
Three cameras are used to photograph the bottle from three sides.

3

Fig. 3:
Hot ampoule in production. (Photos 2 and 3: OTTO GmbH).





Figs 4a and 4b: Photographing objects at different distances from the lens. Without a telecentric lens (4a): the ratios of reproduction are different. With a telecentric lens(4b): the objects are imaged with the same reproduction ratio.

aligned or turned for the measurement. In addition, the space available for a measuring instrument is extremely small for technical reasons. Finally, the high temperatures of the bottles and the surrounding area make very exacting demands on any measuring technology used.

It was for these reasons that the company OTTO GmbH developed a non-contact optical inspection technique on the basis of digital image processing. CCD matrix cameras with telecentric lenses generate two-dimensional images of the test object, from which the image processing software gathers dimensional information and compares it to target values and tolerance ranges. The glowing containers with temperatures of up to 500 °C travel past the lenses at a distance of 180 mm to 250 mm! Specially coated glass protects them from the intense heat.

Non-contact precision

The containers leaving the machine have different distances from, and different orientations relative to the cameras and lenses. With traditional standard optics, this would result in systematic measuring errors which could lead to incorrect sorting. OTTO GmbH solved this problem through the use of telecentric VISIONMES® measuring lenses from Carl Zeiss: Irrespective of the production-related distance of the bottles from the lenses, they are always imaged with the same, unaltered size. This allows measuring accuracies of up to 0.02 mm, depending on the feature being measured, e.g. the bottle height, the diameter in various planes, the outer and core diameter of the thread, the bevel of the bottle mouth, and many more besides. Theoretically, the hot end inspection systems can be used to record, measure, evaluate and sort 900 and more articles a minute. In practice, the machines in the container glass industry currently produce no more than 600 bottles a minute.

Dr. Roland Fiedler of OTTO GmbH played a decisive role in the development of the measuring technology: "We currently know of no setups which can achieve equivalent qualitative and quantitative results in the hot area of container glass production."

OTTO GmbH Computer Vision Systems.

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In short

In many areas of industrial metrology, automation technology, in-process inspection and control, and in quality management, the proportion of optical, non-contact processes now being used to identify, test and measure complex structures is increasing. Such advanced measuring and inspection tasks as the application described here can only be performed using high-resolution CCD camera systems and telecentric precision lenses. The exacting demands made on the measuring system are met by the virtually distortion-free VISIONMES® lenses. Telecentric viewing and the measurement of relevant production processes eliminate the need for costly and time-consuming alignment and testing processes for the user, and higher quality is achieved in the entire production process and therefore also in the products themselves.

VISIONMES®
Telecentric Components

E-mail: petermann@zeiss.de

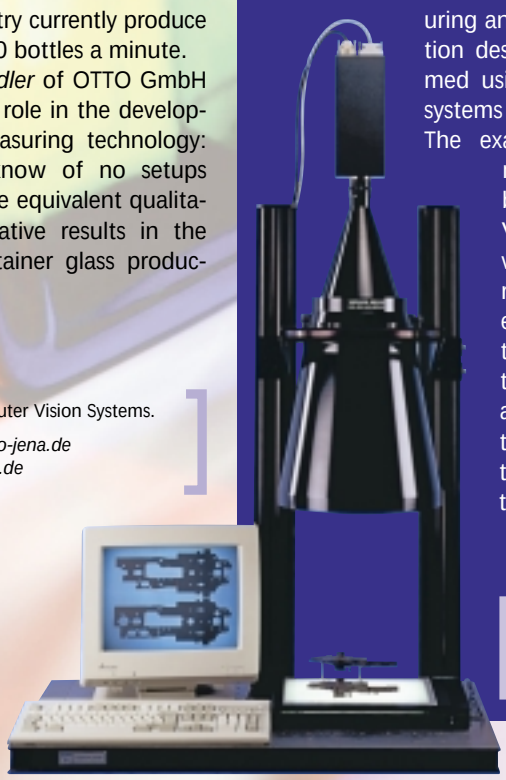

Fig. 5: VISIONMES® telecentric lens from Carl Zeiss.

Always Knowing Precisely How Fast the Earth is Turning

Since October 2001, the world's largest and most precise ring laser has been sited deep under the earth at Wettzell in the Bavarian Forest mountains. Built by Carl Zeiss and implemented by the German Federal Cartography and Geodesy Office, the Technical University of Munich and the University of Canterbury, New Zealand, the large "G" ring laser measures the earth's rotation with unprecedented accuracy. Its data is used, for example, by satellite-based navigation systems such as GPS (Global Positioning System) which rely on global reference systems. The ring laser's measurements are also of interest to earthquake researchers.

"G" for gigantic is indeed an accurate way of describing the new ring laser from Carl Zeiss: with its size of 4 x 4 meters and its weight of more than 10 tons, it rests on a 10-ton granite slab which is supported by a pier founded 11 meters deep – and it is able to measure variations in the earth's velocity of rotation within a range of only 0.1 milliseconds.

This level of accuracy is vital for the implementation of a high-precision global reference system which takes into account even the minutest fluctuations in the earth's rotation. The cause of these fluctuations lies in the constant displacement of masses on the earth's surface (produced by e.g. tides, weather phases, lunar phases) and inside the earth (convection currents, continental drift, volcanic activity, etc.). For the exact determination of a position on the earth, even such slight fluctuations need to be included in the computation. One example: due to the earth's rotation, a point on the equator travels a distance of roughly 40,000 km within 24 hours, or a distance of over 460 meters within one second.

To permit a point to be measured with centimeter accuracy – a requirement for advanced Global Positioning Systems – it must be possible to describe the earth's velocity of rotation to the nearest 20 millionth of a second. This is an accuracy level where even slight variations in the earth's rotation have a noticeable effect in the course of the day. With such critical accuracy requirements, the criteria to be applied to the measuring equipment and its direct environment are particularly stringent. Nothing must influence the measurement result. The geometry of the ring laser itself, for example, must not change in any way as a result of expansion or contraction of the material. Even changes totaling a mere millionth of a millimeter would affect the measurement result. This is the reason why the ring laser's centerpiece is a 10 ton heavy disk of Zerodur® ceramic glass manufactured by the company Schott Glas in Mainz. Zerodur® features virtually zero expansion, roughly 600 times less than steel and 400 times less than optical glass.

Further factors influencing the measurement result are the temperature and air pressure. Even fluctuations of more than one thousandth of a degree Celsius or more than 0.1 hPa have a detrimental effect. To minimize the atmospheric pressure fluctuations caused by weather conditions to 0.1 hPa, the developers enclosed the complete ring laser by a steel tank whose internal pressure is kept constant at 1050 mbar by a control system. The temperature is kept stable by insulation of the laboratory room's concrete walls and ceiling using a thermal layer of Styrodur with a thickness of half a meter, followed by a one-meter thick layer of humid clay and again half a meter of Styrodur. In addition, the complete underground laboratory was covered by a 4 meter layer of soil.

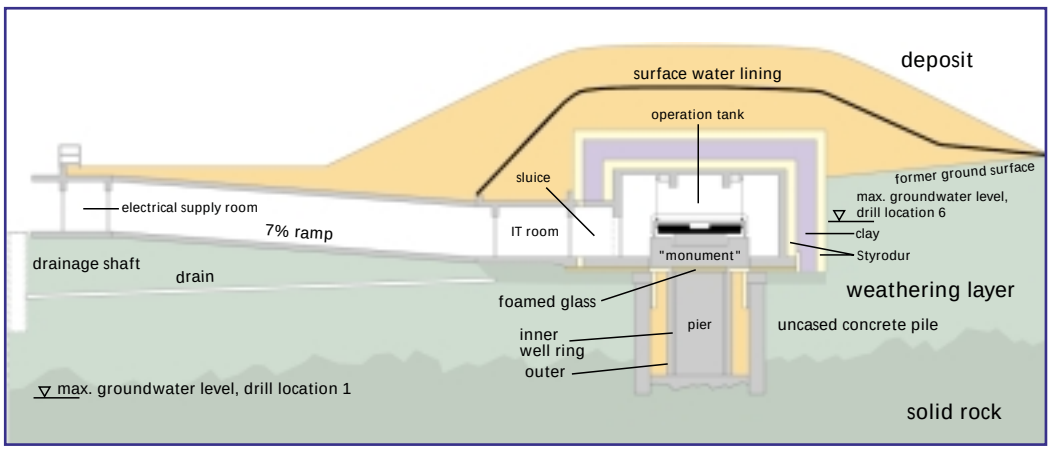

Fig. 1: Schematic section of the underground laboratory for the large ring laser. (Drawing: ifag).

Fig. 2:
10 tons of Zerodur® ceramic glass, the carrier for the ring laser, suspended on the lifting gear of a special-purpose crane on their way to the underground laboratory. In the background, the radio telescope of Wettzell fundamental research station which receives satellite signals from space for earth and ground measurements.

The measuring principle: differences in frequency between two counter-circulating laser beams

Four highly reflective mirrors form a closed beam path running in what is called the resonator tube and enclosing a square surface (ring laser). The resonator tube is filled with an inert gas mixture of helium and neon. The laser or inert gas is excited by a high-frequency voltage in the radio wave range. Since no preference is given to any direction of circulation, the resulting red laser beam starts to circulate in both of the possible directions in the ring-shaped resonator. If the instrument was stationary, the frequencies of both the clockwise and counterclockwise beam would be identical. Due to the earth's rotation, however, the two laser beams travel on paths of different lengths. The resulting path difference is measured in frequencies (Sagnac effect). The Sagnac frequency is directly proportional to the earth's rotation, which means that any variation in the earth's rotation leads to a change in the path difference and therefore in the Sagnac frequency. The large ring laser permits frequency fluctuations of 10^{-9} Hertz to be measured in one day.

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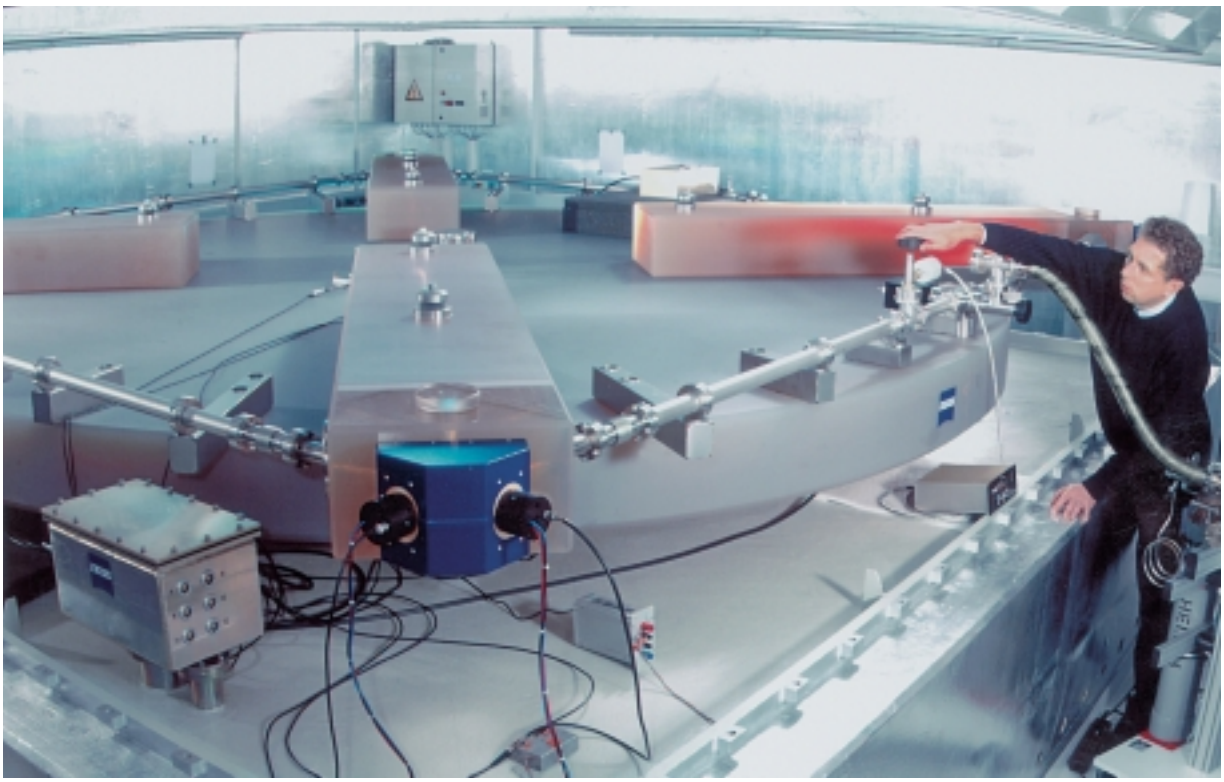

Fig. 3:
The large ring laser permits fluctuations in the earth's velocity of rotation to be measured with extremely high accuracy. Together with the instrument, *Dr. Ulrich Schreiber*, scientific director of the ring laser project at the Research Institute of Satellite Geodesy of the Technical University of Munich.

Measuring Next to the Machine

Bernd Balle

Expectations on today's production measuring technology are largely focused on shopfloor application and the rough environmental conditions encountered there. The trend is obvious: measurement is being shifted from the metrology room into the manufacturing process, which considerably reduces reaction times.

The field of production metrology ranges from the inspection of testpieces in the metrology room to statistical process control. Today, it is still the metrology engineer who uses a coordinate measuring machine in the metrology room for checking the features defined by the designer and produced by the machine operator, but production planners are now claiming that this quality assurance process should be implemented by using measuring machines integrated directly into the production line. In addition, quality engineering is characterized by an increasing trend toward not simply measuring and inspecting workpieces, but monitoring the overall manufacturing process in volume production, allowing early intervention, if necessary. Efficiency is the main reason for integrating coordinate measuring machines into the production process. The closer your measuring technology is located to the production facility, the more directly your process control can be implemented.

Accurate and robust

Apart from the relevant software, it is above all the coordinate measuring machines themselves which have to cope with constantly new challenges. Carl Zeiss launched ScanMax® back in 1997 – a manual measuring machine for in-process inspection. The integration of the measuring machine right in the center of production provides quality information without any need for the metrology room detour. Measuring machines from Carl Zeiss are used like production equipment. For this purpose, the foremost demand on a coordinate measuring machine is resistance to ambient conditions – much like a machining center.

Just envisage the following scenario: it is hot, the machine is causing not only an incredible noise, but also floor vibrations. At times, temperature differences of up to 10 °C prevail, workpieces are covered in lubricants and solvents. And it is in precisely these adverse conditions that high accuracy measurements need to be performed.

CenterMax® does precisely that – a coordinate measuring machine that can be used without an air-conditioned cabin.

The new CenterMax® production measuring center is based on the proven PRISMO® series with the VAST® sensor system. The machine was designed as a bridge construction to withstand the rough ambient conditions in production. Its body consists of a cast stone – a material which is ideal as a thermally and dynamically protective damping element. Like the human skeleton, CenterMax®'s TRF structure provides a thermally stable frame that guarantees the specified accuracy over the entire temperature range. Raised guideways additionally reduce moving masses and therefore enhance the stability and precision of

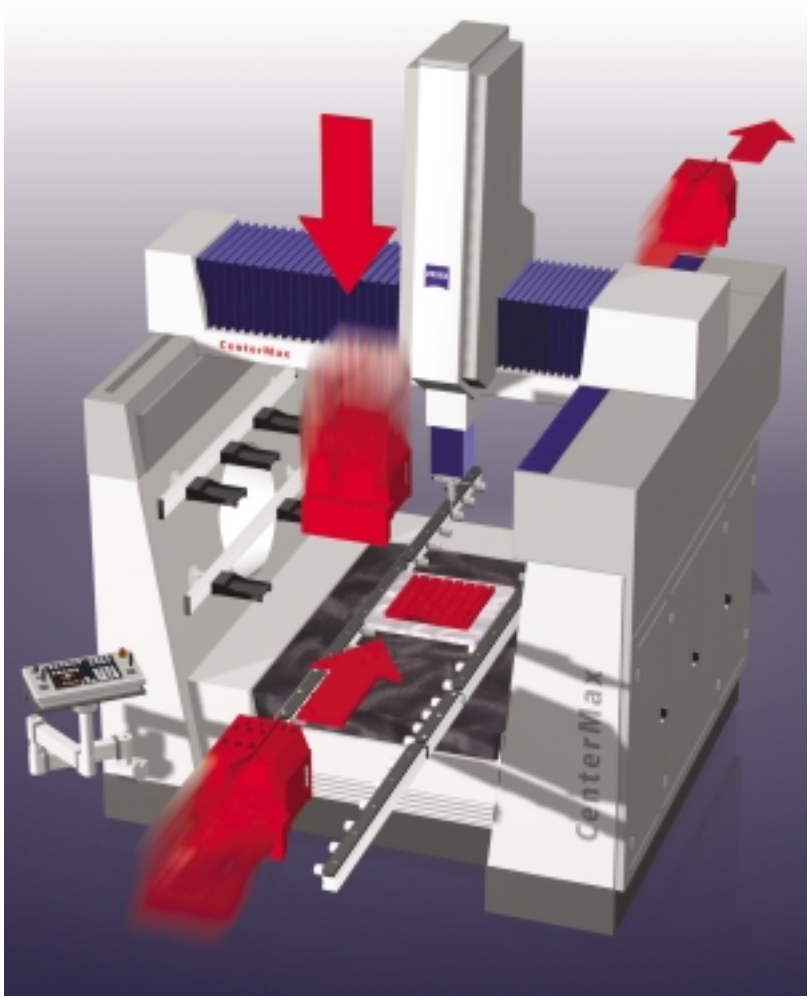

Fig. 1:
Optimized measuring range and enhanced loading capability with CenterMax®.

the coordinate measuring machine. An active vibration damping system makes CenterMax® insensitive to the usual floor vibrations.

Patented labyrinth sealings completely enclose the bearings and scales protecting them against dust, lubricants and solvents. This design also permits liquids such as oil or water to be collected underneath the workpiece base.

To guarantee the optimum ratio between installation area and work range, the measuring volume was optimized. Neither the stylus changing magazine, the rotary table nor the loading system restrict the measuring volume. Therefore, the effective measuring volume corresponds to the nominal volume. A plate carrier frame, a granite plate or a rotary table can be optionally integrated into the machine bed of CenterMax®. Due to its open design the machine can be loaded from three sides.

The new TVA (Temperature Variable Accuracy) specification defined by Carl Zeiss provides CenterMax® with guaranteed accuracy specifications graded according to the given temperature conditions. In the past, the accuracy specification of a coordinate measuring machine referred to the most favorable ambient conditions. If the temperature changed, you could never be sure exactly how accurate your machine was measuring. Now you can specify the appropriate accuracy as a function of the temperature at the site of installation.

The system is equipped with a LCD touch screen for maximum ease of operation, even allowing the operator to wear gloves. CenterMax® operates with the Zeiss-patented active scanning technology which yields information on dimension, form and location in just one measuring process. With stylus extensions up to 450 mm and stylus configurations up to 600 g, the VAST® sensor system provides an answer to virtually all requirements. Compared to doghouse gauges, it is hence possible to verify not only one particular workpiece type, but all parts of your production program. Many gauges, multi-feature measuring devices or test configurations are no longer required. The result: CenterMax® pays for itself in next to no time.

Initial on-site experience

Pilot installations of CenterMax® on different users' premises substantiate the correctness of the design. At Grüner Systemtechnik GmbH in Bad Überkingen, a supplier to all renowned car manufacturers in Germany, a first machine is being used with great success in the middle of the production area. It has been installed exactly where the work needs to be done. Although exposed to rough manufacturing conditions, the machine has been operating faultlessly from day one.

Peter Haller, Metrology Room Manager of Grüner Systemtechnik GmbH, Bad Überkingen, Germany.

"We have compared CenterMax® with PRISMO® and found that we are actually getting the same results with CenterMax® in the production area as with PRISMO® in the metrology room. It measures with the same precision. This was revealed by a long-term test over a period of 6 months."

Bernd Balle, Carl Zeiss Industrial Measuring Technology, Business Strategy Marketing

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Fig. 2: CenterMax® in the center of production.

All Sights Set on Minimum Angles

The performance of computers is rising constantly, thanks to ever smaller structures on the microchips. To generate these finer structures using lithographic methods, the semiconductor industry is utilizing ever shorter wavelengths for exposure. To achieve this, however, the lenses which direct the light on to the chips must also constantly be improved. This requires that their optical properties be known more exactly. However, as the refractive indices of glass batches vary too much to allow the production of high-quality lenses, research staff must determine the refractive index of individual glass batches with extremely high precision. The measurement result is then used for computing the final figure of the lens element, ensuring the correct polishing of the element. Carl Zeiss has now made this high-precision measurement possible for the vacuum UV wavelength of 157 nm.

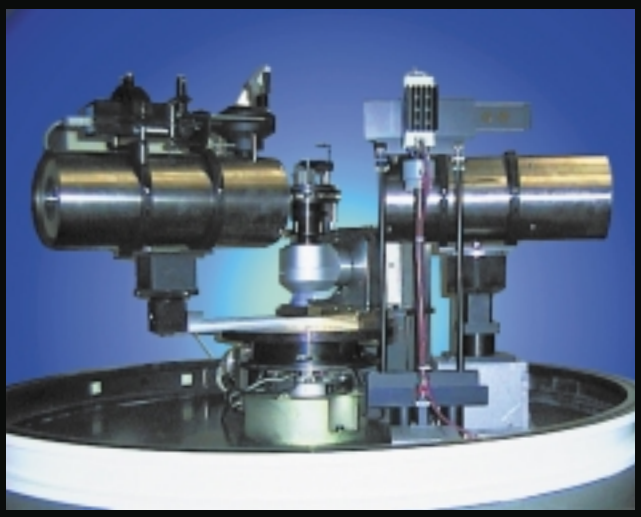

Fig. 1:
The refractive index measuring station is approx. 2 m x 2 m large and weighs approx. 2 tons due to its granite baseplate. One collimator weighs approx. 20 kg.

Take a circle and divide it into about 4 million parts – this will give you some idea of the minute range in which the researchers of Carl Zeiss perform their refractive index measurements. It is their goal next year to make the production of lens elements possible which will allow the critical dimensions on the chip to be reduced even further: The distance between the individual lines is to be clearly shorter than 120 nm. This is 1/300th of the breadth of a human hair. In a few years, this distance is to shrink to only 70 nm (1/500th of a hair's breadth). Wavelengths of 157 nm and shorter will then generate these finest features on the chips.

High-precision refractive index measurements of vacuum UV transparent materials

The development team of Carl Zeiss looks back on three to four years of intensive engineering work and successful cooperation ventures with companies from various sectors of industry. It was a long way from the basic idea behind refractive index measurement to the finished measuring station. *Dr. Martin Ross-Messemer* of the Carl Zeiss Optical Research Division explains: "The idea of refractive index measurement was in fact developed by Fraunhofer as early as 1817. However, improving the measurement has only been possible by using electronics, industrial metrology and the intensive use of computers." To achieve their goal, scientists and engineers had to perform calculations and measurements down to the very last detail and develop new components at many stages.

As the 157 nm wavelength lies in the vacuum UV range and is absorbed by normal air, the measurement of the refractive index is performed in a nitrogen atmosphere. In addition, the ambient temperature and the pressure of the gas used must be exactly determined and taken into account in the computation. For a true comparison of different materials, the air pressure and the temperature must be kept constant. Deviations of as small as 0.1 hPa and 0.1 °C will significantly change the result.

The rotary stage on which the newly developed collimator is mounted can resolve angles of 0.3" (= 1.5 µrad). As the detector for the incident light consists of a highly developed camera system, a problem arose: One pixel of the camera corresponded to an angle of 15 µrad. To be able to approach the resolution provided by the collimator despite this handicap, the research staff developed the subpixel evaluation process, allowing them to measure even these small angles with this camera.

The wide wavelength range from 850 to 120 nm to be covered required a new optical concept for the collimators used in the measuring station, as they should be independent of the ambient temperature and the wavelength used. Zeiss found a solution to this problem in cooperation with the company Lichtenknecker: Using mirrors instead of the usual lens elements in the whole optical system, the researchers circumvented the problem of the different refraction of different light wavelengths, thus creating an achromatic system. The researchers used special steel (INVAR) to mount the mirrors, rendering the system athermal. In addition, the mirrors were specially coated for the vacuum UV range.

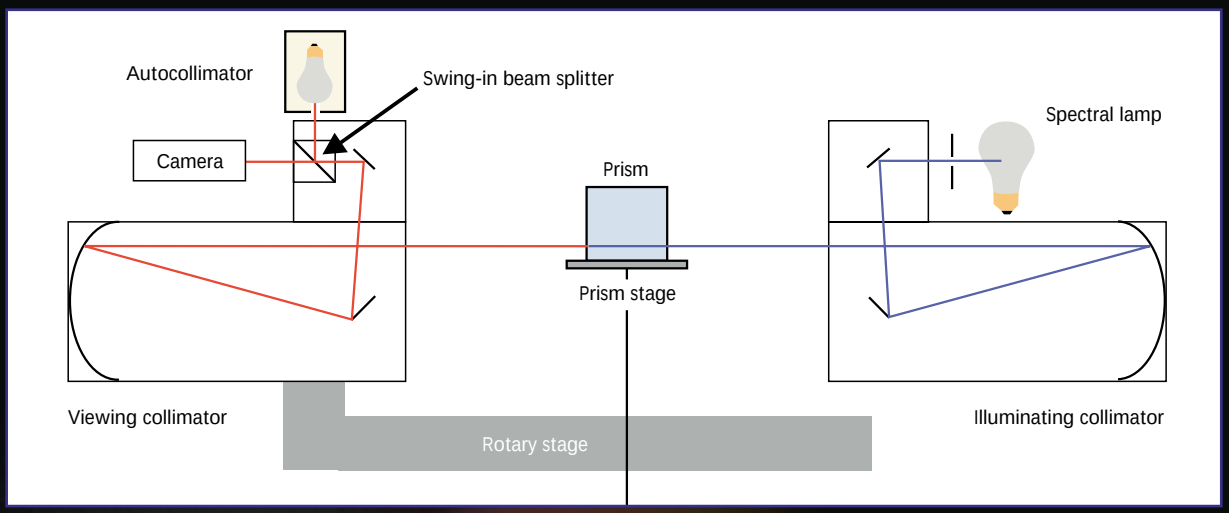

Fig. 2:
Sketch of the refractive measuring station.

For the range between 850 nm to 180 nm, Zeiss developed a new spectral lamp together with the company Heraeus. A different solution was again found for wavelengths below 180 nm: An American company supplied a multiline source which provided a large number of overlapping emission lines. A computer-assisted procedure specially developed by Zeiss allows the individual emission lines to be identified like fingerprints and to be used for measurements. As the individual emission lines have different intensities, a problem arose regarding the light sensitivity of the camera used as the detector. Together with the company Proxitronic the device required was developed.

This completed the number of units needed for the refractive index measuring station. The material to be examined was cut into prisms and placed on the measuring stage. – To create constant conditions for the measurements, the researchers designed a huge steel bell (similar to the tank of a milk truck) and in this way protected the whole system against ambient effects.

Not only had all instruments including those determining the ambient conditions to be connected with each other, but also with a control unit – and then linked to a computer which performs the precise evaluation of the data. The computer, in turn, controls the measuring stage supporting the collimators – a real tour de force also regarding the programming work involved.

The effort was worthwhile: the glass material can be measured with ultra-high precision. In addition, with its refractive index measuring station, Zeiss is involved in international projects in which only the best of the best participate. For instance, even the Physikalisch Technische Bundesanstalt (PTB, German National Metrology Laboratory) compares their measurement results with those obtained by Carl Zeiss. The measuring station can be used in many different areas: from the calibration of spectral lamps and the analysis of gas properties in the VUV range to the examination of the thermal behavior of specific glass types or newly developed materials such as synthetic crystals. This service is also available to Zeiss customers. Info: kalibrieren@zeiss.de

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News from Switzerland

Traditionally, Germany's southern neighbor has been a very good market for Carl Zeiss. As far back as spring 1914, when the new Zurich University building was being constructed, the first Zeiss products – microprojection instruments and reflected light projectors – were delivered to Switzerland. The firm Ganz & Co in Zurich represented Carl Zeiss very successfully for over four decades. In 1958 it was transformed into the Ganz-Optar AG stock corporation, from which Carl Zeiss Zürich AG emerged as the Swiss subsidiary of Carl Zeiss, Oberkochen in 1970.

Today, with a workforce of 80 people, Carl Zeiss AG in Switzerland generates sales totaling 30 million Swiss franks. It is based in Feldbach on the shores of Lake Zurich, where the two sales organizations of Carl Zeiss and Schott Glas operate from one building (Fig. 1). In 2000 two profit centers of Carl Zeiss AG, i.e. Industrial Measuring Technology and Medical Systems, were honored for their exceptional performance compared to other Zeiss European sales organizations.

Fig. 1:
Current headquarters of Carl Zeiss AG, Switzerland on the shores of Lake Zurich.

Fig. 2:
New customer service center for industrial measuring technology on modern premises in Feldbach.

Fig. 3:
Kreuzlingen Planetarium under construction. Planned opening: spring 2002.

Fig. 4:
Successful microscope sales by telephone.
(Photos: Carl Zeiss AG, Switzerland).

IMT in new customer service center

In September 2001 the Industrial Measuring Technology division relocated from Wetzikon to the firm's Feldbach headquarters. It opened a service center with five new measuring, demonstration and training rooms. *Heinz J. Widmer*, President of Carl Zeiss, Switzerland and head of the IMT profit center: "Our goal is continued growth in the field of customer services. In future, we will not only train our customers, but will also perform measuring and programming tasks for them." Small wonder that his staff have no reason to complain about a lack of work. A wide selection of courses, contract measurement and application programming for the creation of customer programs is being very well received by industry.

Planetarium at Lake Constance

Above the town of Kreuzlingen with a breathtaking view of Lake Constance, a Zeiss planetarium will be opened in May 2002. It is the third in Switzerland. In addition to a large star theater in Lucerne, a second, small planetarium was opened in Schwanden in the mountains surrounding Bern in October 2000. Audiences in the 70-seat Kreuzlingen Planetarium can see up to 7000 stars on the dome. Meditative insights into the universe and a special children's program round off the exciting program.

Microscope sales: Success by telephone

One year ago Carl Zeiss AG began an interesting experiment: simple microscopes for school, university, laboratory and hobby use, in particular the Stemi® DV 4 stereomicroscope and the Axiostar® transmitted-light microscope, were sold by telephone by a special trained team of office sales staff. Needless to say, it is not enough to simply wait for telephone calls. Direct mailings were sent to the appropriate target groups, and the DV 4 or Axiostar® was placed at the disposal of opinion leaders and students on special terms and conditions.

The result after one year: sales totaling around DM 1 million and an eight-fold increase in market share in the lower price segment of stereomicroscopy. 50% of business is generated with microscopes, the other 50% with colposcopes and lens analyzers. The office sales staff achieved this sales performance with existing personnel capacities and substantially eased the workload of field staff.

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Zeiss Microscopes at Yale University

In New Haven, at the Yale University School of Medicine, an exhibit on "Microscopy: Tools of the Biomedical Sciences" was organized in honor of the university's 300th anniversary. Opening day ceremonies were highlighted by a lecture on "The Evolution of Infectious Disease" by *Dr. Joshua Lederberg*, Nobel Laureate for Medicine in 1958 and former president of the Rockefeller University,

The exhibit was supported by an educational grant from the Carl Zeiss Foundation. Not only historic instruments sent on loan to New Haven by the Optical Museum of Carl Zeiss, Oberkochen, but also state-of-the-art microscopes from Carl Zeiss were displayed. Carl Zeiss, Inc., Thornwood provided confocal and fluorescence and stereo microscopes, including the new PALM system with a laser scalpel. A look at the future of instrument development in the field of microscopy rounded off the exhibit.

Fig. 1:
Dr. Norbert Gorny, Member of the Board at Carl Zeiss and Executive Vice President and General Manager in the Microscopy business group, presents a replica of the Zeiss Stativ Microscope VII from 1880 to *Dr. Martin Gordon*, director of the Yale Medical Library, and *Dr. Joshua Lederberg* (from left to right).

Net: www.med.yale.edu/library/zeiss

Fig. 2:
Historical microscopes and state-of-the-art systems for biomedical research were exhibited at Yale University.

Fig. 3:
Surgical microscopes and ophthalmic instrument systems rounded off the exhibition. (Photos: Carl Zeiss, Inc., Thornwood).

Reopening Celebration in Big Style

Fig. 1:
James McDonnell Planetarium in St. Louis.

Fig. 2:
Guests at the reopening ceremony included *Wilfried Lang*, Manager of the Planetarium Business Unit, and *Dr. Franz-Ferdinand von Falkenhausen*, President and CEO of Carl Zeiss Jena GmbH (from left).
On the lectern: *Douglas R. King*, Director of the Science Center.
(Photos: Ann Wagner).

On June 22, 2001, the James McDonnell Planetarium in St. Louis in the US state of Missouri reopened its doors with a totally new look. The complete revamping of the building also included the installation of a new Universarium Mark IX projector. This makes the St. Louis Science Center one of only four large planetariums worldwide boasting this type of projector.

Major challenges await the Universarium in St. Louis. The presentation concept of this extremely successful science center is based on edutainment: the aim is to present the world of the stars in a way that appeals to the senses, thus achieving a greater understanding for it. Visitors will be surprised to find, for example, that there are no seats in the McDonnell Planetarium. They can watch the starlit sky either standing up or lying on their backs, or from a platform accessible with an elevator. All presentations lasting 15 to 20 minutes are live shows during which the preprogrammed projections of the sky and astronomical phenomena are explained by the operator of the projector. The audience has an opportunity to ask questions during the show. And that is not all: to answer the questions, the content of the projection can be instantaneously adapted to the issue discussed – one of the many benefits of the Universarium. Another unusual feature of the new facility is the lack of fixed program structures. The presentation room is always open and never completely darkened to make it easier for the audience to find their way about. Nevertheless, the Zeiss Universarium reproduces the stars with unprecedented brilliance.

Roughly one million visitors every year have gained new insights into the laws and processes of astronomy in the James McDonnell Planetarium. This number may well increase with the new projector.

Net: www.slsc.org
Net: www.zeiss.de/planetariums

10th Anniversary at Carl Zeiss Jena

Lothar Janiak

Carl Zeiss Jena GmbH has celebrated its 10th anniversary. This may be only a short time compared to the 150-year history of Carl Zeiss as a whole, but it has been an important period which has shown that, after the collapse of the "combine" in former East Germany and German reunification, the company with a long, prestigious past also has a future in Jena. The short 10-year history of Carl Zeiss Jena GmbH is a real success story. Today, the Carl Zeiss Group is recording a level of growth and income unequalled in the past five decades. *Dr. Bernhard Vogel*, the Premier of Thuringia, the German federal state in which Jena is located, summarized the situation as follows: "A sad symbol of German partition has become a symbol of modernity with its focus firmly on the future."

Fig. 1:
Thuringia's Premier, *Dr. Bernhard Vogel* (center), was welcomed to the 10th anniversary celebrations by Carl Zeiss President and CEO, *Dr. Dieter Kurz* (left), and the President of Carl Zeiss Jena GmbH, *Dr. Franz von Falkenhausen*.

The development of Carl Zeiss Jena GmbH was a major entrepreneurial challenge. The Zeiss spirit has proven to be an important propelling force in this critical situation. The years immediately after reunification were difficult. Full integration into the Carl Zeiss Group cost much more money and lasted longer than expected. After years of running at a loss with the necessary personnel adjustments, problems in the Group as a whole in the mid-nineties further aggravated the situation in Jena. The turnaround came with the decision of the Board of Management in 1995 to give the Jena subsidiary more responsibility for its operations and provide it with more financial backing. The company's portfolio was totally changed in the following years. The targeted transfer of future-oriented, high-tech products from the Group to Jena, the setting up of the new areas Molecular Medicine and Digital Projection Displays and the additional involvement of the Jena location in the successful lithography and laser optics business were all of key importance for the success that has been achieved. Growth in the new areas has led to today's healthy earnings situation. Sales in the past fiscal year topped the € 250 million mark for the first time.

Fig. 2:
In his speech the Commissioner of the Carl Zeiss Stiftung, *Dr. Heinz Dürr*, thanked everyone who had contributed to the success of the Jena company.

Fig. 3:
Carl Zeiss invited the residents of the region to attend an Open Day organized in celebration of the company's 10th anniversary. (Photos: Peter Poser, Jena).

Lothar Janiak heads the Central Communications area at Carl Zeiss Jena.

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Red Dot Awarded Twice

Fig. 1:
CenterMax® coordinate measuring machine.

Two new products from Carl Zeiss were presented with the international "red dot" award of the Design Center of North Rhine-Westphalia for superb design quality.

Firstly, it was awarded to the recently launched CenterMax® coordinate measuring machine. In its development, acknowledged as "high design quality" by a prestigious jury, Carl Zeiss cooperated with the Henssler & Schultheiss design office. The synergy of state-of-the-art technology and good design was one of the reasons for the positive response during the product launch and was followed by multiple orders from major customers such as the car manufacturer Ford and the supplier Alsthom.

The second instrument to be awarded the "red dot" was the S7 floor stand for ophthalmic surgical microscopes. An international jury came to the conclusion that the S7 floor stand combines leading edge technology with a modern, elegant and durable design. Sealed and smooth surfaces are major benefits during cleaning at the end of a day's work in the OR.

Fig. 2:
International "red dot" design award.

PRISMO No. 2000 for DaimlerChrysler

Not many coordinate measuring machines can enjoy such overwhelming market success as the machines of the PRISMO® series. In October 2001, Carl Zeiss Industrial Measuring Technology delivered the 2000th unit of this series to the Hedelfingen plant of DaimlerChrysler – only one and a half years after the delivery of PRISMO® No. 1000.

Fig. 1:
Presentation of the 2000th PRISMO® CMM with a protective full enclosure for use directly on the shop-floor under very harsh ambient conditions.
From the left: *Alexander Heeg*, Carl Zeiss; *Gerhard Müller*, *Gerd Becker*, *Armin Ilg*, all DaimlerChrysler; *Dr. Rainer Ohnheiser*, Carl Zeiss Manager for Bridge-type CMMs; *Ralf Dieter*, President and CEO of Carl Zeiss Industrial Measuring Technology; *Norbert Weis*, DaimlerChrysler.

PRISMO® has set standards in industrial measuring technology: this extremely flexible, universal machine for cutting-edge accuracy requirements in production and process control is suited not only for the verification of individual features on a part, but also for the fast and highly precise inspection of complex workpiece geometries in their entirety. Its foremost success factor is the VAST® scanning technology developed by Carl Zeiss 25 years ago and optimized since then on an ongoing basis. With the world's most successful scanning probe, dimension, form and location can be measured in one chucking.

Optics Gold Award

Fig. 1:
Since May 2000, the Lens Compendium Online has been presenting complex subject matter and answering special questions on the subject of ophthalmic optics in an easy-to-understand way with the aid of clear, explanatory illustrations and diagrams.

In 2001 the Compendium Online received the "Optik-Award in Gold" and was declared Germany's best industrial web site in the ophthalmic sector. The internet-supported reference work for all matters associated with ophthalmic optics and products is the first winner of this new award. After a nomination procedure in which over 1,600 surfers took part, the jury consisting of staff from leading German ophthalmic journals presented the Optics Gold Award to the Carl Zeiss editorial team.

The Optics Award, an initiative of the ophthalmic internet portal Optik-Net (www.optik-net.de), is presented to web sites in the sector which excel through their creative design, ambitious content or the many benefits which they offer the ophthalmic sector. *Patricia Perlitschke*, editor of the German journal Deutsche Optikerzeitung DOZ and jury member, commented as follows on the presentation of the award to Carl Zeiss: "We were particularly impressed by the successful balancing act between a creative web design on the one hand and the clear, factual arrangement of information on the other. This offers exceptional benefits to the surfer."

The Carl Zeiss eyeglass lens compendium went online for the first time in May 2000. Since then the level of interest showed in it has continued to rise. It can be found in the internet at www.zeiss.de/compendium.

What visitors to the compendium are saying:

"A really super reference work with many interesting details. Just what I've always wanted."

"What I've seen till now has been very clearly presented and informative. Congratulations!"

"...I'll most certainly use it often, as at long last I've found a site that answers all my questions."

Otto Schott Research Award

Fig. 1:
Presentation of the Otto Schott Research Award in 2001: award committee member *Prof. Dr. Gerd Müller*, *Dr. Boris Anatoljevich Shakhmatkin* and *Dr. Natalia Mikhailovna Vedishcheva*, Institute of Silicate Chemistry of the Russian Academy of Sciences, St. Petersburg, *Prof. Dr. Reinhardt Conradt*, Institute of Mineral Engineering, Chair of Glass and Ceramic Composites, RWTH Aachen, Germany, and Member of the Schott Board of Management, *Dr. Udo Ungeheuer* (from left to right).
(Photo: Schott Glas).

The chemical composition of glass determines its properties. But how are the various constituents interrelated? And what effect do structural changes have on the properties? In the past, time-consuming experiments were required to discover the relationship between new structures and their properties – no mean feat for glass materials comprising many components. Reliable results in a much shorter time are now promised by thermodynamic models, the inventors of which have received the Otto Schott Research Award 2001.

Professor Dr. Reinhard Conradt of the RWTH Aachen, Germany was selected for the award "for his conception of a highly versatile approach to thermodynamic modeling of oxide melts and glass based on constitutional relations of equilibrium phases and for the pioneering results achieved by this approach in the evaluation of physical and chemical properties, particularly chemical resistance, of technical multi-component glass."

The Russian team, *Dr. Natalia Mikhailovna Vedishcheva* and *Dr. Boris Anatoljevich Shakhmatkin*, received the award "for the development of a rigorous thermodynamic model of oxide melts and glass based on compound equilibria and for the impressive results obtained by applying this model to the evaluation of physical properties of two-component glass forming systems".

Both models allow, on the one hand, glass properties such as volume, thermal expansion and thermal capacity to be derived solely from the glass synthesis and the thermodynamic data of the corresponding oxide systems. On the other hand, parameters that are very important to the glass-melting process can be predicted.

The Carl Zeiss and Otto Schott Research Awards, to which the sum of €25,000 has been allocated, are each presented once every two years on an alternating basis. They were created to motivate primarily young scientists in recognition of outstanding work in the fields of glass, glass ceramics and optics.

Carl Zeiss Research Award Followed by Nobel Prize

Fig. 1:
Eric A. Cornell, winner of the Carl Zeiss Research Award in 1996 and the Nobel Prize for Physics in 2001.

For the generation of a new state of aggregation of matter known as the Bose-Einstein condensate, the German physicist *Wolfgang Ketterle*, Massachusetts Institute of Technology, and the two US research scientists *Carl E. Wiemann* and *Eric A. Cornell*, University of Colorado in Boulder, received the Nobel Prize for Physics in 2001. This condensate, which was already predicted in 1924 by *Albert Einstein* and the Indian physicist *Satyendra Nath Bose*, is the fifth form of matter to be discovered in addition to solid, liquid, gaseous and plasma.

In 1995, the prize-winners succeeded in producing the Bose-Einstein condensate for the very first time. As long ago as 1996, *Cornell* received the Carl Zeiss Research Award for this achievement. After *Ahmed Zewail*, he is the second scientist to become a Nobel Laureate after winning this international award funded by the Carl Zeiss Foundation since 1988.

Research is now being performed to find applications for the Bose-Einstein condensate. An atom laser which can generate extremely fine structures with atomic accuracy would permit considerable advances to be made in nanotechnology, while quantum computers point the way to a totally new quality of data transmission.

Prize-winning Micrograph of a Hamster's Eye

Fig. 1:
2nd prize in the light microscopy competition from Olympus and Nature: micrograph of a hamster's optic nerve papilla and the retinal regions surrounding it, taken with an Axioskop® FS, 10x objective Plan-NEOFLUAR®, SPOT-2 camera.
(Micrograph: E. Cho).

The micrograph of a hamster's retina taken with a Zeiss microscope by *Professor Eric Cho* from the Chinese University in Hong Kong won second prize in the worldwide Micrography Competition 2000 organized by Olympus and Nature magazine. Both the excellent technical quality of the micrograph and its interesting scientific background were the major factors for the jury's decision. The micrograph shows the close interrelation between the retinal ganglia cells with their axons (red) directing the light signals to the brain, and the astrocytes (blue) and blood vessels which are recognizable by the processes of the astrocytes surrounding them. *Cho* obtained this interesting photo by using immunofluorescence to visualize the axon bundling in the optic nerve papilla and the progress of the blood vessels via the papilla into the retina and out of it.

Carl Pulfrich Award 2001

The Carl Pulfrich Award 2001 went to *Dr. Claus Brenner*. This was the first time after a 4-year interval that this award of major importance to the world of photogrammetry, geography and cartography has once again been conferred. Following an international invitation for entries, an independent international committee unanimously selected the winner from the proposed candidates in honor of his outstanding achievements in the field of three-dimensional building reconstruction.

Fig. 1:
Presentation of the Carl Pulfrich Award 2001 to *Dr. Claus Brenner* by *Rudolf Spiller*, President and COO of Z/I Imaging GmbH. On the right: *Prof. Dr. habil. Dieter Fritsch*, President of the University of Stuttgart and Director of the Institute of Photogrammmetry.

The Carl Pulfrich Award, to which the sum of DM 10,000 has been allocated, was awarded for the 16th time this year, but for the first time by the Carl Zeiss joint venture company Z/I IMAGING, the successor to the Carl Zeiss Photogrammetry Division. The presentation of the award took place during the opening ceremony of the Photogrammetric Week.

The Carl Pulfrich Award was created in 1969 to emphasize the importance of the industrial manufacture of surveying and photogrammetric instruments not only for this specialist field, but also for the economy of our country in general, and to promote the close links between science, practical application and industry. The award is named after *Prof. Dr. Carl Pulfrich* (1858-1927), who initiated the manufacture of surveying and photogrammetric instruments at Carl Zeiss in Jena around 1880.

Cooperation with the Nobel Foundation

In future Carl Zeiss and the Nobel Foundation, represented by the Nobel Foundation Museum Association, will cooperate in expanding the virtual Nobel-e-Museum (http://www.nobel.se).

The Nobel-e-Museum aims to acquaint a wider public with the discoveries in science and research for which Nobel Prizes have been awarded. The Internet is the ideal medium for illustrating the complicated facts which lie behind discoveries that have received Nobel prizes. In some cases, practical examples and even games are used to explain the problems involved. To make the scientific achievements of the Nobel Prize winners readily understandable to everyone, easy-to-read texts, clearly laid-out graphics and video animations are offered.

Carl Zeiss will support the production of Internet pages in the new section "Science & Technology" not only financially, but also by providing documentation. Here, the focus will be on discoveries made in optics and microscopy. For instance, a virtual electron microscope will allow surfers to learn by mouse click how to use the microscope and how a microscope of this type functions.

The central subject of the new web sites will be the relationship between basic research and technical implementation. This applies in particular to the optical instruments which helped the Nobel Laureates make their pioneering discoveries in biology, physics and chemistry, or which were themselves developed on the basis of new discoveries. One example of this is the microscopic contrasting technique invented by the Dutchman *Dr. Frits Zernike* in 1933, for which he was awarded the Nobel Prize in Physics in 1953. In cooperation with the inventor, a prototype of the first phase contrast microscope was developed at Carl Zeiss. The Nobel-e-Museum will provide detailed information on this contrasting technique which is now indispensable in routine microscopy.

This cooperation between Carl Zeiss and the Nobel Foundation has been launched to celebrate the Centennial of the Nobel Prize, the first international award for outstanding scientific achievements. The agreement will last for several years.

Carl Zeiss Acquires Metrology Division of HK-Technologies Ltd., England

In July 2001, Carl Zeiss acquired the prestigious and successful metrology division of HK-Technologies Ltd. in England, formerly Hahn & Kolb. With this acquisition, Carl Zeiss will continue the successful 30-year business relationship on a new basis. New company facilities in Rugby will contain not only the demo center, but also a training center. The customers of Carl Zeiss Industrial Measuring Technology now have a direct contact with the manufacturer in all questions regarding sales, training and service.

Carl Zeiss Ltd.
Division of Metrology
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Lenses for the Digital Cinema

Carl Zeiss and Band Pro have concluded a cooperation agreement on the development, production and marketing of high-performance lenses for digital high-definition cine cameras. In this cooperation, Carl Zeiss, the leading manufacturer of 35 mm lenses for cine cameras, will be responsible for the development and production of the lenses. Band Pro Film/Video of Burbank, California, will be responsible for global marketing and sales. For over 17 years, Band Pro has pioneered film-style electronic cinematography systems including the Sony CineAlta 24p HDCAM™ and is therefore familiar with this market. Carl Zeiss' contribution to this partnership is its superior know-how in practically all important segments of the still and cine camera markets for which the company develops and manufactures lenses. In the next few years, it is expected that there will be a boom in digital cinema films, resulting in an accordingly high level of demand for high-performance lenses meeting the requirements of digital cinematography.

Net: www.bandpro.com

The World's Most Modern Cine Camera

The most modern cine camera comes from Germany. The lenses for this camera are supplied by Carl Zeiss. The ARRICAM launched by the company Arnold und Richter in Munich is a modular 35-mm camera system which features an exceptionally large number of innovations. In addition to the usual precision and reliability provided by ARRI, electronic help functions ensure extremely high operating convenience. The additional digital modules enable the cameraman to choose those which he really needs.

For the very first time, a lens control system has been directly integrated into a camera which can record and control the settings of the mounted lens. In the new LDS ULTRA PRIME lenses (Lens Data System) from Carl Zeiss, sensors ensure the constant non-contact measurement of the focus, aperture and focal length settings of the zoom lens and feed them back to the camera.

As the first professional studio camera, ARRICAM will provide an electronic focusing aid from fall 2002. Instead of the tape measure previously used, the distance between a handheld unit and the camera is measured at the press of a button using ultrasound. At the user's request, the distance is also set immediately on the lens – only one example of the perfect system integration provided.

The hallmarks of the ARRICAM Studio camera for work using a tripod are an especially low noise level and its enormous variety of functions. The ARRICAM Lite is ideal when weight, size and freedom of movement are major considerations, for example when a Steadicam or shoulder-mounting camera is used.

Fig. 1:
The LDS ULTRA PRIME lenses from Carl Zeiss for the ARRICAM have been fitted with sensors which perform non-contact measurement of the focus, zoom and aperture settings and transmit this data to the camera via an electronic interface in the PL mount. (Photos: ARRI)

Net: www.arri.com

Fig. 2:
Fred Schuler, ASC, shot the film GERMANIKUS in the Cinecitta studios in Rome in summer 2001 – this was the feature film premiere for the ARRICAM system with the newest LDS Ultra Primes from Carl Zeiss. The film will open in movie theaters in spring 2002.

Fred Schuler, Director of Photography, ASC:

"The ARRICAM system enables direct contact to the camera in all important areas and extends my creative possibilities. It is more compact, lighter and as a result better to handle.

The LDS Ultra Prime lenses offer great advantages in focusing. You can work much more precisely and quickly because you can read all the relevant data at a glance In total, a comprehensive and complete system which covers all areas of use."

An Old Telescope Advertises a New Financial Group

Bringing the benefits of a large bank closer to the customer – this is the message conveyed by an advertisement of the HVB Group which shows the 600 mm reflecting telescope with a 300 mm tracking telescope installed at the Svábhegy Observatory in Budapest, Hungary. The telescope's optical system and the dome were supplied by the company Carl Zeiss back in 1928.

Formed by the merger of HypoVereinsbank with Bank Austria, the HVB Group is one of the three largest banks in Europe and is also present all over the world. The financial group aims to be a modern, European network of regional banks. Size combined with proximity – this is symbolized by the old Budapest telescope to this very day: it gazes into the depths of the universe and brings information on distant objects down to us on earth.

Fig. 1:
This advertisement of the HVB Group showing an old Zeiss telescope appeared from May to November 2001 in major German and European print media such as The Economist, Business Week, Financial Times Europe, Wall Street Journal Europe, Handelsblatt, Frankfurter Allgemeine Zeitung, etc.
(Photo: HVB Group).

HypoVereinsbank Puts Its Money on Zeiss

A photograph of the inspection microscope for microelectronics, the Axiotron® 2, is shown in an ad with the headline "Invest now in technology that deserves your money." Activest, the investment group of the German bank HypoVereinsbank, is using this ad to promote the newly established fund Activest EuropeTech in major German newspapers, the Wirtschaftswoche, Managermagazin, Focus money and other magazines. This stock fund is focused on European technology stocks and invests in the most innovative and promising suppliers of European high technology. The selection of one of the innovative microscopes from the Carl Zeiss Microelectronic Systems division for the ad shows that these products are evidently ranked as the top of the line in leading-edge technology.

Fig. 1:
The photos for the Activest product ad were taken in the Ferdinand Braun Institute for Maximum Frequency Technology in the Berlin-Adlershof Technology Park, Germany. The photographer was Ralph Baiker. (Ad: Scholz & Friends, Berlin).

Best Result Ever in the Company's History

Marc Cyrus Vogel
Vice President & General Manager, Corporate Communications, Carl Zeiss

At the end of the year 2001, Carl Zeiss presented itself as an innovative company with strong growth and high profits. Innovative products and the systematic customer focus of all Zeiss activities resulted in increased sales in all product groups.

With its six business groups, the Carl Zeiss Group is positioned in the four strategic markets Life Sciences and Health Care, Eye Care, Semiconductor and Optoelectronic Technology, and Industrial Solutions. In addition to the highly profitable Semiconductor Technology group, the business groups Microscopy, Medical Systems, Industrial Measuring Technology and Opto-Electronic Systems also contributed to the healthy result. The frontrunner in growth was the Microscopy business group in a marketplace that showed a high level of demand triggered by pharmaceutical and genetic research across the globe.

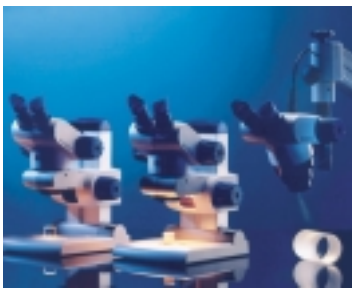
Compared to the previous year, net income doubled to €110 million. Sales rose by 3% to €2.056 billion. The other figures also show a pleasing, positive trend. Incoming orders rose by 5% to €2.191 billion, and the operating result improved from €120 million to €172 million. Equity was increased by over €100 million. On the balance sheet date, the Carl Zeiss Group employed a global workforce of 14,200 people, including 10,100 in Germany.

Carl Zeiss aims for growth through technology and innovation. Spending on research and development rose by 5% to €146 million which is equivalent to 7% of sales. Innovative strength is an important success factor for Carl Zeiss. In the 2000/01 fiscal year, the company generated 43% of its sales with products launched on the market in the past three years. The competence of Carl Zeiss offers the company an opportunity for further business expansion.

Net: www.zeiss.de

Light Microscopy

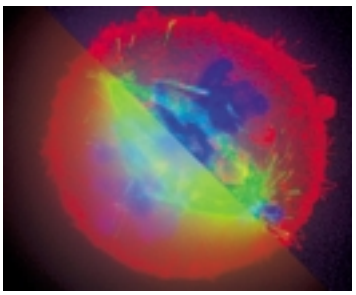
The small Stemi® DR and Stemi® DV 4 stereomicroscopes provide uncompromisingly brilliant and clearly defined images, sturdy, hard-wearing technology and the very easy operation of all controls. Four basic models are available to the user: the Stemi® DR 1040 with a 10x overview magnification and a 40x magnification for observing details, Stemi® DR 1663 with 16x and 63x magnifications, and the Stemi® DV4 with a patented zoom system (magnification range between 8x and 32x). Combined with the new compact Stand C allowing the change between reflected, transmitted or mixed light at the press of a button for the first time, these instruments provide a new dimension of quality in the operation of modern stereomicroscopes. The Stemi® DV4 SPOT additionally features a fiber-optic illuminator integrated into the front lens system and is therefore ideal for applications with special boom stands and in the OEM field.



The product family of Stemi® DR and Stemi® DV4 stereomicroscopes.

The digital AxioCam® MRc and MRm color and Peltier-cooled monochrome high-performance cameras meet a wide variety of customer requirements with a cost/benefit ratio never achieved before. The 12-bit digitalization is performed directly in the camera head and permits image and color quality far beyond the possibilities of standard video cameras. Furthermore, the AxioCam® MR provides a large number of resolvable brightness levels and – a unique feature in this price category – a 36-bit color depth. In addition, the long, variable exposure times are not provided by standard video cameras at all, and only partly by other digital cameras in this price segment. The AxioCam® MRm monochrome version is particularly beneficial in fluorescence applications. The photographic conditions can be reproduced quickly and easily, making this camera ideal for routine applications.

The AxioCam® MRc digital camera.



Triple labeling of cultured cells (CHO Chinese Hamster Ovary cells) before and after 3D deconvolution.

3D Deconvolution is innovative deconvolution software to improve image quality in fluorescence microscopy. Compared to previous deconvolution systems, this new software offers major benefits in both its functionality and operating convenience. The major functions include the automatic reading of all recording parameters from the image data, the preview or Region-of-Interest function (ROI), the calculation of the I-divergence and automatic calculation stop when the optimum image quality has been achieved, and the possibility of sequentially calculating all the fluorescence channels and times of time-lapse imaging – either individually or as a whole.

The AxioVision® Viewer software for the viewing of photomicrographs taken and saved (zvi-format) with AxioVision® software can now be downloaded free of charge in the Internet at http://www.zeiss.de/viewer. The software permits images and image details such as scale and recording parameters saved in AxioVision® image formats to be displayed, printed and exported. As with the AxioVision® complete version, the entire information is also available without restriction during image viewing.

Ophthalmology

The FF 450plus fundus camera provides optimum performance for the observation and photography of the fundus, combining high-quality optical components with outstanding operating convenience. The three field angles are used to change the view of the field in steps, with the smallest field angle providing a markedly higher resolution and making even the finest details of the eye clearly visible. The fundus image can be easily adjusted without any reflections, and digital photography, archiving and processing open up new possibilities for displaying and documenting the findings. The video adapter is suitable for use with 3-CCD cameras, digital cameras and special viewfinder cameras. The newly introduced boost mode allows optimum light efficiency in late-stage photos taken in fluorescein or ICG angiography and thus reduces the flash energy – important for decreasing the patient's exposure to light. One special benefit provided by the system: the findings are immediately available with high quality after examination of the patient's eye, allowing therapy to be immediately initiated.

FF 450plus fundus camera.

At the beginning of 2002, the VISULAS 532s will replace the VISULAS 532. The main application of this solid-state laser is coagulation on the fundus of the eye (e.g. in diabetic retinopathy). The major benefits provided by the new laser are not only its "small size", "low weight" and different setups, but also the VISULINK 532/U link system and a transport case. Customized solutions are available to all target groups for the setup, use and accessories of the laser.

VISULAS 532s ophthalmic laser.

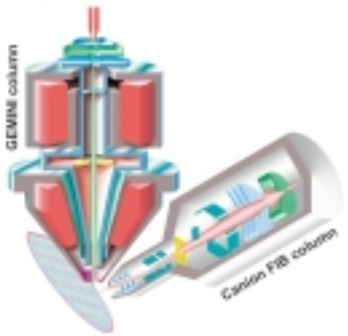
Surgical Products

The S7 floor stand for ophthalmic surgical microscopes is ideal for use in the ORs of hospitals and by office-based ophthalmologists. The user-friendly electronic system allows the instrument settings to be adapted to the needs of the ophthalmic surgeon – also during surgery. This stand eliminates time-consuming adjustments before every surgical procedure. And to top it all: Should the main lamp fail, a backup lamp is automatically swung into the beam path, allowing the surgical procedure to be continued uninterrupted. Cleaning of the floor stand is also facilitated, as the light guide and power supply cables are concealed by elegant, free-form surfaces.

S7 floor stand for ophthalmic surgical microscopes.

Electron Microscopy

The LEO 1560XB CrossBeam Workstation is a double-beam unit with two columns on one common specimen chamber. The electron-optical (GEMINI) and the ion-optical (Canion 31 Mplus from Orsay Physics) columns have been mounted at a defined angle in such a way that both beams cross on the sample at a short working distance. Major applications for this new instrument combination include the high-resolution imaging of specimens using electrons and ions, the cross-sectioning of defined sample areas using an ion beam and the targeted deposition of metals or non-conducting materials. The LEO CrossBeam Workstation provides a number of outstanding features such as maximum resolution for imaging with electrons and ions, high ion current for rapid analysis, viewing during the simultaneous use of the electron beam and the ion beam, the examination of magnetic specimens, precise work with fully motorized, super-eucentric 6-axis specimen stage, high stability and easy operation.



Setup of the GEMINI and FIB columns in the LEO 1560XB.

Camera Lenses

The world's smallest and lightest camcorder is equipped with a 2.3 – 23 mm Vario-Sonnar® f/1.7 lens. The DCR-IP5/DCR-IP7 models from Sony are 10.3 cm high and tip the scales at a mere 310 g. They use mini-tape technology with Micro MV tapes which provide a recording time of up to 60 minutes and to which MPEG2 data is written. Despite this, they meet the demands of even the most discerning user. www.world.sony.com

Sony DCR-IP7 camcorder. (Photo: Sony).

The design of the DigiPrime™ lenses for high-definition cinematography fully utilizes the creative and technical potential of the best HD cameras featuring 2/3" chips. Equipped with a B4 mount, the mechanical interface for the camera, the DigiPrime™ lenses will provide special features for film-style cinematography using high-definition cameras. The first products will be fixed-focal-length high-performance lenses and are scheduled for delivery in late summer 2002. www.digiprimes.com.

Sports Optics

High optical performance, compactness and low weight are the hallmarks of the Diascope® spotting scopes which are available in four versions. Both the two compact scopes with 65 mm dia. objective lenses and the two high-power models with 85 mm dia. objective lenses are available with eyepieces for straight or angled viewing. Discerning birdwatchers prefer the Diascope® 65 T* FL or 85 T* FL models combined with an eyepiece for angled viewing. As hunters and enthusiastic nature observers are mostly on the same level as the game they are watching, these users will particularly appreciate the Diascope® 65 T* FL and 85 T* FL spotting scopes with eyepieces for straight viewing. The combination of T* multilayer coating and fluoride glass material provides the lenses of the Diascope® spotting scopes with superachromatic properties. Two matching wide-angle eyepieces with fixed powers and one zoom eyepiece are available for all scopes – each with a bayonet mount for rapid change and with a safety catch.

Diascope® spotting scope.

Victory Compact 8 x 20 B T* and 10 x 25 B T* binoculars.

The functional and elegant design of the new generation of pocket binoculars comprising the Victory Compact 8 x 20 B T* and 10 x 25 B T* models immediately betrays their kinship with the large Victory binoculars. Like their big brothers, they feature matte, black rubber armoring which is pleasant to hold and ensures a secure grip in rainy or cold weather. The Victory Compact binoculars are dust-proof and waterproof. They are filled with nitrogen to prevent any fogging of the optics in the event of severe temperature fluctuations. The T* multilayer coating on all lens elements and prisms of the optical system guarantees a crystal-clear, razor-sharp image with maximum color fidelity. Special eyepieces with push-pull eyecups ensure that eyeglass wearers can also enjoy a full field of view. The shortest focusing distance, only 2.6 m in the 8 x 20 B T* and 4.0 m in the 10 x 25 B T*, turns these binoculars into telemagnifiers, allowing users to view insects and other small creatures close-up without disturbing them.

High performance, low weight and compactness are the hallmarks of the three riflescopes of the Conquest® line. They were made possible by a redesign of the optical system and the use of glass material which is free from lead and arsenic. With a large eye relief, wide fields of view, peak transmission values and an attractive cost/benefit ratio, these new riflescopes meet hunters' demands during long periods of stalking in wide open plains and for hunting in the mountains. The Conquest® 3-9 x 40 MC is the classic multi-purpose riflescope with a power of 3x to 9x. Thanks to an objective lens diameter of 40 mm, the image provided is still bright and brilliant in poor light. The Conquest® 3.5-10 x 44 MC is a powerful all-round riflescope. Due to its 44 mm objective lens diameter, this riflescope is ideally suited for use at dawn and early dusk. The Conquest® 4.5-14 x 44 MC is a variable-power riflescope with a high magnification and the riflescope of choice for hunting small game at long ranges.

Conquest® 3.5-10 x 44 MC Silver mounted on a Blaser all-weather rifle (nickel-plated).

Ophthalmic Products

The progressive eyeglass lens Gradal® Individual is now also available in glass with the refractive index 1.6. In the design of this lens, not only the wearer's refraction data, but also the various parameters obtained in the fitting process are taken into account in the surface computation. Such fitting parameters as the pantoscopic angle or tilt of the frame, back vertex distance, PD, frame dimensions and near object distance are all taken into consideration in the surface design of Gradal® Individual. In addition, the progressive surface is calculated for each individual power. This means that substantially larger ranges of vision are possible in the near, intermediate and distance zones, providing the wearer with unparalleled visual comfort.

The earth's rotation is fluctuating –