A GERMAN-US FACULTY/INTERN EXCHANGE PROGRAM IN BIOTECHNOLOGY

J. Collins[1], T. Giorgio[1], P. King[1], J. Alley[1], H. Lauten[1,4], P. Winter[2], A. Appenzeller[2], J. Scriven[3], R. Jonas[3], C. Berger[4], P. Eichelmann[4], H-J. Jacobsen[5], B. Huchzermeyer[5]
[1]Vanderbilt University, Nashville, TN/[2]Carl Duisberg Gesellschaft, Hannover, Germany/ [3]National Research Centre for Biotechnology, Braunschweig, Germany/[4]Solvay Pharmaceuticals, Hannover, Germany/[5]University of Hannover, Hannover, Germany

ABSTRACT

A consortium for exchange of student industrial interns and academic and industrial expertise in biotechnology and bioengineering education has been established between the NSF-funded VaNTH Engineering Research Center in Bioengineering Educational Technologies and an alliance of universities and trade organizations in Niedersachsen, Germany. The purposes of this consortium are (1) to supplement VaNTH domain expertise in biotechnology, (2) to explore differences in European/US models of bioengineering and biotechnology education and attitudes toward biotechnology development, and (3) to provide students opportunities for internships in other countries. (1) The expertise of authors H-JJ and BH in plant biotechnology and biochemistry will supplement that of VaNTH biotechnology domain leader author TG in the creation of biotechnology learning materials. Exchanges of US and German faculty and students for short courses will also take place. (2) A workshop of scientists and educators from the U.S. and Germany is being organized for Fall 2002 in Germany to introduce and allow input from the European engineering education community to VaNTH, and to address controversial aspects of biotechnology such as stem cell research and genetically modified food. US and European policies and public opinion toward both these issues differ substantially and will benefit from scientific and other discussion. (3) US intern, author HL, works with Solvay Pharmaceuticals in Hannover, Germany and is mentored by author CB. Other positions in Germany are being sought for US students. European engineering students previously hosted by author PK have been well-trained in research and industrial applications and are desirable interns for both US engineering design courses and US companies.

GOALS OF THE PARTNERSHIP

We have established a partnership between the VaNTH ERC in Bioengineering Educational Technology and a consortium of German universities, research institutes, and companies in the cities of Hannover and Braunschweig in the German state of Niedersachsen. Participating German institutions include the Technical University of Braunschweig, the University of Hannover, the National Research Centre for Biotechnology (GBF) in Braunschweig, and the Carl Duisberg Society (CDG) in Hannover. The goals of our partnership are (1) to compare the

VaNTH approach to biotechnology education to the approach of the European scientific community; (2) to expand the knowledge base of the VaNTH domain thrust in biotechnology through the expertise of the partner institutions of the German biotechnology community, and (3) to allow VaNTH and German faculty and students to experience the academic, business and cultural environments of the exchange community.

OVERVIEW OF VANTH, THE GERMAN CONSORTIUM AND THE PARTNERSHIP

The VaNTH ERC. The VaNTH ERC unites educators, experts in learning technology, and bioengineers and professionals in related sciences, in academia and industry, to define and develop bioengineering education for the future by equipping professionals with knowledge and learning methodologies to address demanding issues facing society. Our current partnership is strong, bringing together professionals from four major biomedical engineering programs at five major U.S. universities: Vanderbilt, Northwestern, the University of Texas/Austin, and the HST joint program at Harvard and MIT (hence, the acronym VaNTH) together with learning science, learning technology, and ethics professionals at these universities. Academic partnerships with leading bioengineering programs in the U.S., and industrial and practice partnerships with some of the leading bioengineering, education science and enabling technology companies and laboratories, are being forged.

The German Consortium. The state of Niedersachsen (Lower Saxony) in north central Germany possesses some of that country's greatest resources in biotechnology. Strong educational institutions exist in Hannover (University, medical and veterinary schools) and Braunschweig (Technical University (TU) of Braunschweig). The University of Hannover's expertise in biotechnology extends to plant and environmental biotechnology and biochemistry (see discussion of collaborators below). A comprehensive research institute, the National Research Centre for Biotechnology (GBF) in Braunschweig, is ideally suited to partner. The GBF is an organization of 600 employees (200 scientists) with extensive involvement in both the science and the technology of biotechnology.[1] The GBF's annual budget is roughly $82M DM ($40M dollars, $44M Euro), with approximately 68 percent derived from national, 7 percent from state governments and 25 percent from industry and other sources. The GBF hosts and partially supports TU Braunschweig's Department of Biochemistry. GBF's infrastructure includes central library and computing facilities, a small-business biotechnology incubator with more than 40,000 ft^2 floor space, and a new conference center (August 2000) which can accommodate conferences of up to 350. GBF connections with more than 150 biotechnology companies in Niedersachsen are maintained through the industry organization BioRegioN. A research park adjacent to the GBF campus provides expansion space for incubator companies. Genomics, molecular and cellular engineering, pathogens and vaccines, bioactive compounds, and environmental biotechnology are high-priority GBF research areas. A team of GBF scientists recently received international recognition for the mapping of human Chromosome 21, implicated in Down's syndrome.[2] Recently-appointed director Dr. Rudi Balling brings a record as a top-echelon genomic scientist and a dynamic administrator to the GBF.[3] The GBF has a distinguished history of international collaboration, having fostered international programs to build biotechnology infrastructure in developing countries for many years.[4]
The German consortium also includes a strong coordinating office in Hannover (Carl Duisberg Society (CDG)). The purpose of CDG is to promote international collaborations like the one described here. For more than 20 years CDG has coordinated the Biomedical Sciences Exchange Program (BMEP), in which young physicians and scientists from western Europe and

the U.S. and Canada can hold exchange research fellowships and clerkships. VaNTH institutions are among those who have hosted BMEP scholars. CDG has also facilitated the GBF international exchange programs for biotechnology students from less developed countries for many years.

History and Purposes of the Partnership. In 1998 a trade mission from Niedersachsen visited Nashville and Vanderbilt. Discussions about a student exchange program were initiated. In May 2000 Dr. Peter Winter of CDG visited Vanderbilt and plans for a student exchange program were made more definite. On a visit to Niedersachsen in March 2001, Dr. Jerry Collins of Vanderbilt and VaNTH visited several laboratories and offices in Niedersachsen and invited those interested to participate in the student exchange program and in VaNTH. This program was funded in the U. S. by the NSF as an extension of the VaNTH ERC, and in Germany through the CDG and GDF.

The purposes of the partnership from the standpoint of VaNTH are to take advantage of an opportunity to extend the base of VaNTH knowledge domains beyond the expertise of current VaNTH participants and partners and to expose an important segment of the European scientific community to VaNTH by facilitating faculty and student interchanges between VaNTH and the biotechnology community in Niedersachsen, Germany. The purposes from the German standpoint are to extend the visibility of the Niedersachsen biotechnology community to educational and commercial biotechnology interests in the U. S., to collaborate with U. S. efforts in biotechnology education, and to give German students opportunities for internships in the U.S.

CHALLENGES TO BE ADDRESSED

The discussions that follow describe ways in which challenges inherent in VaNTH and in the establishment of this partnership will be addressed, leading to the strengthening of VaNTH and of the international bioengineering community.

Challenge 1: Extension of the VaNTH Biotechnology Knowledge Domain The VaNTH ERC is responsible for providing educational technologies for bioengineering. The engineering programs of the academic members of the VaNTH consortium are all in biomedical engineering. Expertise in critical areas of non-medical bioengineering, including biotechnology, must be identified outside the VaNTH consortium. Biotechnology expertise within the Niedersachsen consortium extends to plant and environmental applications. Hans-Jörg Jacobsen of the Molecular Genetics Program at the University of Hannover has offered to include U.S. students or faculty in a four-week practical course in plant biotechnology. Topics include explant sterilization, *in vitro* organogenesis, phytohormones, inhibition of polyphenoloxidases, and plant transgenosis. He is also willing to offer a short course in plant biotechnology in the U.S. and interact with VaNTH personnel to incorporate it into VaNTH materials. His departmental colleague Dr. Bernhard Huchzermeyer has offered to provide instruction in plant biochemistry.

Challenge 2: Integrating Differing Models of European and U.S. Engineering Education Substantial differences exist between U.S. and European models of undergraduate engineering education. The U.S. undergraduate degree is typically conferred after the equivalent of four academic years of work. Requirements usually include sequences in the basic sciences physics, chemistry and biology; in mathematics, and in the liberal arts, in addition to a broad initial exposure to engineering culminating in a focus on courses in the declared major (biomedical engineering). Student options depend on particular university requirements and students' own

choices, and may include time spent in industry or other commercial venues, in government or private laboratories, or in clinical settings, as an intern or co-op student.

The European undergraduate engineering experience is usually undertaken after thirteen years of previous training and is typically five years in duration. The first two years of a German bioengineering curriculum would include extensive instruction in chemistry, physics, biology, mathematics and basic engineering. There is little or no exposure to arts and humanities in this curriculum; such coursework is typically encountered in high school. At the beginning of the third year, the student chooses an engineering specialty (such as biotechnology) and is intensely trained in that specialty for three years. Training includes two practical periods. The first, of three months' duration, includes affiliation with a company or laboratory, completion of an assigned task (or tasks), and a written summary of the experience. The second practical may occur in the last six months of the fifth year. Much more is expected of the student in this practical: more extensive involvement with the company or laboratory (not necessarily the same one chosen for the first practical), a greater degree of independence in choice and maturity in execution of the chosen project, and a more comprehensive writeup and reporting. Undergraduate engineering programs in the U.S. and Europe, therefore, differ substantially in duration, content and philosophy. The U.S. undergraduate experience typically leaves the student with a range of choices for career or professional development, including medical school, graduate school in a range of disciplines, or work in one of a variety of marketplace opportunities, not necessarily limited to engineering. In contrast, European engineering training tends to be much more focused on preparation for practice in a particular specialty of engineering. Meaningful student and faculty interaction between European and U.S. engineering academic and industrial sites requires recognition of and accommodation to these differences. Students from the U.S. will be recruited to take short courses and hold research and industrial internships in Niedersachsen. Dr. Jonas, Dr. Jacobsen, Dr. Huchzermeyer, and Dr. Thomas Scheper of the Institute of Technical Chemistry at the University of Hannover are among possible mentors for these students. Student exposure with these mentors will provide valuable experience for the students and mentors. The VaNTH assessment team will provide assessment models for the principals.

Dr. Peter Winter of CDG has solicited German funds for German students to participate in the exchange program. These students will stay for about six months each and will be responsible for conducting a bioengineering design project during that time. A German student will enroll as a student at a VaNTH institution and must spend at least half his/her time (three months) on campus. The remainder of the time can be spent with a company in an internship position, for which work they may receive pay. Dr. Paul King is developing VaNTH materials in bioengineering design. He teaches undergraduate and graduate courses in design, and will oversee the Vanderbilt campus experiences of the German students. He and Dr. Collins will be responsible for recruiting off-campus internship opportunities for these students. Dr. King is experienced with international students, having hosted French engineering students for fifth-year internships for a number of years. He and Dr. Giorgio will also assist Dr. Collins in selecting suitable industrial internship experiences for U.S. students in Germany. German students can also be matched to internships at other VaNTH institutions besides Vanderbilt and can be assisted by industrial internship teams at those institutions. The VaNTH assessment team will provide a model for quantifiable assessment of those experiences as well.

Joint involvement of U.S. and German faculty in preparation of VaNTH learning materials and in mentoring of students from the exchange country will lead to common understanding of and appreciation for the differences in European and U.S. engineering education and create an environment in which constructive dialogue and improvement may occur.

Dr. Todd Giorgio is planning to offer in Germany a series of presentations in biotechnology incorporating the VaNTH learning approach. This course will serve as a test bed for VaNTH material and methodology and is an important first step in creating awareness of VaNTH in Europe.

Challenge 3: Increased Exposure for VaNTH in the European Bioengineering Community
The goal of every Engineering Research Center is to develop state-of-the-art products that will have enduring impact on the market for which they are targeted. In the case of VaNTH, those products are K-12, undergraduate and graduate curricular, and continuing education products. VaNTH is challenged, therefore, to make its educational materials visible and relevant throughout the bioengineering educational and practice community.

A recent report published by Merrill Lynch states: "Unlike the U.S., where postsecondary education is readily available, access to world class postsecondary institutions in many parts of the world is limited. There is insatiable demand for knowledge workers on a global basis and a gross imbalance between what the marketplace demands and current availability. Students abroad are hungry for top quality, and specifically U.S.-based, education. Currently, nearly 500,000 foreign students study in the U.S. and are spending (annually) approximately $13 billion."[5] According to this report, the populations (P), numbers of postsecondary students (S) and postsecondary faculty (F) in the U.S. and Germany in 1998-9 were:

Country	Population	Students	Faculty	S/F	S/P x 100
U. S.	**265 M**	**15 M**	**2.6 M**	**5.8**	**5.66**
Germany	**82 M**	**1.7 M**	**198 K**	**8.6**	**2.41**

These figures compare students in baccalaureate programs (training years 13-16) in the U.S. with students in professional programs (years 14-18) in Germany, which are students' first levels of encounter with intensive training in biotechnology. According to these figures, the U.S. has almost 2½ times as many postsecondary students, and almost 3½ times as many postsecondary faculty, per inhabitant as Germany has. These figures are probably somewhat misleading because of the higher entry level of training required of postsecondary schools in Germany. Similar relationships among students, faculty and population exist in other countries in Western Europe. The disparity between the U.S. and Eastern Europe is even more pronounced. The U.S., for example, has 3 times the postsecondary students and 7 times the postsecondary faculty per inhabitant that Russia has. What does appear to be the case is that through this and similar initiatives VaNTH and Germany have great opportunity to influence biotechnology education, and that VaNTH through this and similar initiatives can become part of the dialogue on the unification of engineering education in Europe.

The inaugural ASEE/SEFI/TUB International Colloquium, "Global Changes in Engineering Education," scheduled for September 15-18, 2001 in Berlin was postponed until October 1-4, 2002 because of the events of September 11, 2001. A contiguous workshop on U.S. and German

biotechnology faculty, student and idea exchange is being planned for October 7-8, 2002 in the new GBF conference center in Braunschweig. The workshop will be internationally advertised and sponsorships are being solicited. The workshop will provide an opportunity to further introduce the European engineering education community to VaNTH and a chance for VaNTH investigators to consider input from European educators and practitioners.

Challenge 4: Addressing Educational and Ethical Issues in Biotechnology As an emerging profession, bioengineering is faced with unique educational issues. The industrial community is often unaware of the unique contributions that bioengineers can make. Many companies are hesitant to hire bioengineers, preferring to hold to the practice of hiring engineers from traditional disciplines such as electrical or mechanical engineering. The public is often skeptical of the effect of high costs of development of new biomedical devices and products on the cost of health care.

The knowledge domain of biotechnology presents perhaps the greatest public and legislative educational and ethical challenges of all the domains of bioengineering. Ignorance and apprehension are widespread. In a recent public poll in Germany, for example, 43 percent of respondents believed that people normally do not possess genes—that genes are incompletely understood, potentially harmful agents introduced during risky treatments. Similar beliefs can be found among the U.S. public, reflective of the general fear that the biomedical research and industrial communities are less than candid about the potential dangers of the products, devices, and drugs they produce.

The two areas in which public skepticism is highest are stem cell research and genetically modified food. Reactions in the U.S. and in Europe differ widely on both of these subjects. In the U.S., opposition to stem cell research (because the best and most easily harvestable sources of stem cells have been human embryos) has been fierce. For a long period, the National Institutes of Health would not fund stem cell research. Modifications in that restriction have been made more recently. In Europe, opposition to stem cell research is less intense and focused. In fact, the British House of Lords passed a resolution in 2001 in favor of allowing human cloning. In contrast, attitudes toward genetically modified food are more negative in Europe than in the U.S. VaNTH shares the responsibility to articulate these issues and contribute to their worldwide public discussion.

Most of the biotechnology expertise of VaNTH members is directed toward human gene therapy. Opportunities to extend knowledge in this domain as well as others are being sought. The described partnership between VaNTH and the German consortium will effectively extend the knowledge base of biotechnology to include plant physiology and biochemistry.
The workshop we are proposing (see above) will devote time and attention to the critical issues of making the public in the U.S. and in Europe more informed about the science of biotechnology and more aware of ethical issues related to genomic science research and development. It will also address the economic implications of public and private expenditures in the area of health care and how technology can promote wiser use of those resources.

Placing VaNTH Students in Industrial Internships Student internships are intrinsically useful. They provide employment and a basis for making career choices for students. Students educated through VaNTH methodologies aid in the assessment function of VaNTH as their employers make judgments about their effectiveness as employees. Techniques learned by students during internships may be incorporated into the knowledge base of VaNTH.

Participation of VaNTH faculty in industrial employment or consultancy roles can enrich VaNTH content and make it more relevant. Broad exposure to a variety of internship opportunities benefits VaNTH in many ways.

Funds from the NSF have been granted to pay travel costs and cost-of-living stipends for five U.S. students for a period of three months each. Dr. Collins is responsible for recruitment of U. S. students for German internships, arranging visa and travel plans, and arranging specific German mentorships for the students. Stipends for U.S. students in Germany have come form the NSF and from German companies. German and U.S. academic calendars are not the same, which may necessitate adjustment of schedules and stays in some cases. It is generally regarded that three months is an absolute minimum period for an internship if it is to be meaningful for the student and useful for the mentor.

Dr. Peter Winter of CDG is soliciting German funds for five German students to participate in the exchange program. Under one exchange plan, a German student will enroll as a student at a VaNTH institution and must spend at least half his/her time (three months) on campus. These students will stay for about six months each and will be responsible for conducting a bioengineering design project during the time spent on campus. The remainder of the time can be spent with a company in an internship position, for which work they may receive pay. Dr. Paul King teaches undergraduate and graduate courses in design, and will oversee the Vanderbilt campus experiences of the German students. He and Dr. Collins will be responsible for recruiting off-campus internship opportunities for these students. Dr. King is experienced with international students, having hosted French engineering students for fifth-year internships for a number of years. He and Dr. Giorgio will also assist Dr. Collins, Dr. Jonas and Dr. Winter in selecting suitable industrial internship experiences for U.S. students in Germany. All VaNTH institutions have industrial internship awards from the Whitaker Foundation. German students holding internships at other VaNTH institutions besides Vanderbilt will be assisted by industrial internship teams at those institutions. The VaNTH assessment team will provide a model for quantifiable assessment of those experiences as well.

The first U.S. intern has already been placed with a German firm. Hunter Lauten received her B.S. in biomedical engineering from Vanderbilt in May 2001. She has experience in the DNA Microarrays laboratory of the Vanderbilt Cancer Center. On October 1, 2001 she began a nine-month internship with Solvay S.A., an international pharmaceutical firm in Hannover, Germany. She is currently working for the pharmaceutical division on the Women's Health Team, doing therapeutic protein research targeted toward cancer treatment. Her work includes tasks such as protein expression, protein purification, cloning, transfection of clones into cultured cell lines and general microbiology procedures/techniques. She is also working on developing a screening assay to test for protein/enzyme inhibitors. In addition to these activities, she is recruiting German companies as hosts for other U.S. interns and recruiting German students for internships with U.S. companies. Other U. S. and German candidates for summer and fall 2002 internships have been identified and stpes are being taken to secure positions for these students.

Challenge 6. Reaching Out to the K-12 Community Every ERC is also charged with the responsibility of reaching out to the K-12 community. VaNTH's K-12 outreach is intended to make bright young students aware of the content and attractiveness of the bioengineering profession. Dr. Huchzermeyer is ideally suited to help VaNTH and the German community in this regard. He is an advisor and author of high school biology textbooks for the Cornelsen

Foundation and is a member of the society Bildung & Begabung (Education and Talent). Both organizations try to improve teaching material in Germany. The Cornelsen Foundation is a private organization. Bildung & Begabung is funded by German industry and the German Ministry of Education.

The main activities of Bildung & Begabung are summer schools for gifted children that offer teaching at university level for last-year high school students. The idea is to help these children find their field of interest and offer a first real challenge. They have observed that gifted children do not learn at school how to handle failing a test, and most school children have no idea what subjects are offered at a university. The result is that many gifted children change subjects as soon as they receive poor marks in a test, and become frustrated when they realize that other students finish university studies in a shorter period of time. The organization cooperates with similar organizations from other European neighbor countries as well as the USA. They invite 10 to 20% participants from abroad provided they are sufficiently fluent in German language.

The research and work of this organization are of interest and importance to VaNTH investigators in both the learning science and K-12 outreach areas. The partnership described here will make the VaNTH and German groups aware of each other and allow them to approach the challenge of reaching gifted young students within the context of bioengineering. Dr. Huchzermeyer will also work with the already well-established K-12 outreach program of VaNTH to make VaNTH biotechnology materials suitable for extension to middle and high school students.

OTHER ASPECTS OF THE PARTNERSHIP

Summary of Roles of the Partnership Team The purpose of the VaNTH ERC is to bring together bioengineering, learning science and learning technology specialists in academia and practice to ask: What do bioengineers need to learn? How can they best learn it? How can learning best be assessed?

The German partners will extend the content of VaNTH curricular bioengineering education, give students experience in industrial and practice internships, and expose gifted students to biotechnology and bioengineering in pre-university years.

Team Qualifications Dr. Collins, as industrial liaison for the VaNTH ERC, is the appropriate person within VaNTH to conduct this project. For several years he has been chair and member of the Interface with Industry and the Education committees of the Biomedical Engineering Society. He is the recipient of a Whitaker Foundation award to develop an industrial internship program for the Department of Biomedical Engineering at Vanderbilt University. These responsibilities, particularly those concerned with internships, led him to pursue the development of a student internship exchange program between Vanderbilt and Niedersachsen. Dr. Giorgio, the biotechnology thrust leader of VaNTH, is preparing curricular materials and continuing education courses in biotechnology. Dr. King is leading the development of design courseware within VaNTH and has many years' experience in overseeing design projects and case-study experiences for both U.S. and European student engineers. VaNTH learning science, learning technology, bioethics and assessment experts are consulted as necessary.

The CDG has coordinated international student and scientific exchange programs for more than 20 years, and Dr. Peter Winter is the appropriate CDG official to coordinate this partnership from the German side. Dr. Rainer Jonas, scientific information director of the GBF, coordinates the development of new businesses within the GBF incubator and oversees contact with more than 150 German biotechnology companies through BioRegioN. He is the appropriate person to coordinate student internship experience from the German side. Dr. Hans-Jörg Jacobsen and Dr. Bernhard Huchzermeyer have expertise in plant biotechnology, and interest and experience in presenting biotechnology information to the German public, especially high school students.

Creative and Original Concepts From the VaNTH standpoint, the partnership represents the first concerted opportunity to introduce VaNTH activities and concepts to the European educational and practice community. It will expand the bioengineering knowledge base of VaNTH, address complex issues of public awareness and education in bioengineering, particularly biotechnology, and provide enrichment to U.S. and German students and faculty through short course and internship exchange programs.

There is a great match of VaNTH and German interests in establishing the bioengineering knowledge base, communicating its importance within the economic, political and social environments of the U.S. and Germany, representing accurately and enthusiastically the profession of bioengineering to young people, and developing industrial and practice internship experience for students. This described partnership is a logical extension of all these interests.

Benefits to Society The intellectual and cultural interchange engendered by this partnership will enrich the educational and industrial bioengineering communities of both the U.S. and Germany. VaNTH teaching materials will be enriched and made more suitable for both U.S. and European use.

The biotechnology workshop will bring about increased awareness of the benefits and limitations of biotechnology in both the U.S. and Germany. Discussions directed at allaying fears and increasing understanding should be of enormous benefit to a public lacking in basic understanding, skeptical or unreasonably hopeful about issues such as gene therapy and genetically modified food, and irrationally frightened of epidemics such as the spread of bovine spongiform encephalopathy. In particular, the synthesis of U.S. and European approaches has the capability of enlightened both communities in ways that a single-nation approach would not.

SUMMARY

Engineering has become a global practice. The proliferation and growth of international corporations, the opportunities for international business activities, and the expansion of free trade have all contributed to a climate of 'business without borders." Opportunities to share faculty experience, student training, and international attitudes about technology such as those in our exchange program are a necessary step in the globalization of engineering education.

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BIOGRAPHICAL INFORMATION

J. COLLINS is a faculty member in biomedical engineering at Vanderbilt University, Nashville, TN.

T. GIORGIO is a faculty member in biomedical engineering at Vanderbilt University, Nashville, TN.

P. KING is a faculty member in biomedical engineering at Vanderbilt University, Nashville, TN.

J. ALLEY is with the Department of Biomedical Engineering, Vanderbilt University, Nashville, TN.

H. LAUTEN was a student in biomedical engineering at Vanderbilt University, Nashville, TN and is now an intern with Solvay Pharmaceuticals, Hannover, Germany.

P. WINTER is director of development at the Carl Duisberg Foundation, Hannover, Germany.

A. APPENZELLER is with the Carl Duisberg Foundation, Hannover, Germany.

J. SCRIVEN is with the German Research Center for Biotechnology, Braunschweig, Germany.

R. JONAS is head of scientific information at the German Research Center for Biotechnology, Braunschweig, Germany.

C. BERGER was formerly with Solvay Pharmaceuticals in Hannover, Germany.

P. EICHELMANN is with Solvay Pharmaceuticals in Hannover, Germany.

H-J. JACOBSEN is professor of molecular genetics at the University of Hannover, Hannover, Germany.

B. HUCHZERMEYER is professor of botany at the University of Hannover, Hannover, Germany.

This project was supported in part by the Engineering Research Centers Program of the National Science Foundation under award number EEC-9876363, by an Industrial Internship Award from the Whitaker Foundation, by the Carl Duisberg Gesellschaft, Hannover, Germany, and by the National Research Centre for Biotechnology, Braunschweig, Germany.