THE US-EC TASK FORCE ON BIOTECHNOLOGY RESEARCH 1990-2010

Biotechnology Research For A Complex World

JUNE 2, 2010

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1. CO-CHAIRS' FORWARD

The establishment of the European Commission (EC) - United States (US) - Task Force on Biotechnology Research in 1990 came at a time when the world was changing dramatically. The rapid advances in global computing and communications that altered every aspect of daily life presented new opportunities for scientific coordination and collaboration. The genomics revolution, which allowed scientists to investigate the structure and function of organisms on a genome-wide scale, was also marked by an increase in international cooperation, initially because of the sheer scope and cost of the first projects. Rapid advances in global computing and communications and the genomics revolution two decades ago offered new opportunities for international cooperation, and the European Commission and the White House Office of Science and Technology Policy seized them by setting up a forum for policy makers and scientists from Europe and the US to exchange ideas and to spur the full development of biotechnology to the benefit of society.

Nobody expected that this Task Force would develop into a unique "think tank" on Biotechnology Research, a think tank that has covered emerging, innovative fields such as bioinformatics, neuro-informatics, nano-biotechnology (a term that was coined by the Task Force), mapping of the human brain, marine biotechnology, and biodiversity genomics. Over the years, major societal concerns have been addressed, such as emerging infectious diseases, nutrition, obesity, biotechnology for cleaning-up pollution, as well as bioethics, the role of women in science, and public perceptions of biotechnology. What makes this Task Force unique is its focus on challenges that are global and where biotechnology can make a contribution. Now it is the rule rather than the exception for scientific research and training to be international in participation and scope. Today's challenges of global climate change, the need for new sources of

energy and bio-based materials, as well as healthy food for the growing world population know no national boundaries and are of a magnitude that no one country can tackle alone. The Task Force continues to serve as an important think-tank focusing on the future of biotechnology, challenging the broader scientific community to expand its thinking beyond specific disciplines.

This report highlights the role of the US-EC Task Force in bringing together researchers from both sides of the Atlantic to anticipate the needs of tomorrow's science today. The focus is on the activities of the past decade since the publication of the decadal report “The EC-US Task Force on Biotechnology Research - Mutual Understanding: A decade of collaboration [1990-2000].” After two decades, the longer term impacts of Task Force activities are clearly visible. Young scientists that were trained in some of the first workshops are now leaders in their fields and continue the dialog that they began as students. The emerging fields of bioinformatics and genomics have become intertwined with many of the working group activities, enabling new discoveries with potential downstream societal benefits. At the heart of all of this work has been a rich and vibrant collection of working groups whose enthusiasm and commitment have maintained the momentum and impact of the Task Force’s activities. As we celebrate the accomplishments of the Task Force at twenty years, we also look forward to the challenges of the next decade and see that the need for the forum it provides for scientific cooperation is stronger than ever.

Judith St. John
US Co-Chair
Associate
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2. ABOUT THE US-EC TASK FORCE

The US-EC Task Force is a bilateral consultative mechanism that was established in 1990 by the European Commission and the White House Office of Science and Technology Policy with the goal of promoting information exchange and coordination between biotechnology research programs funded by the European Commission and the United States government. Initially, it was envisioned as a think-tank in which scientists and administrators could share research outcomes and directions emerging from funding on either side of the Atlantic. A detailed report on its first decade can be found in the report entitled "The EC-US Task Force on Biotechnology Research – Mutual Understanding: A decade of collaboration [1990-2000]." [1, 2]

In the past twenty years the Task Force has accomplished its goals through a wide range of activities that have included scientific workshops, short-term fellowships, training courses and research programs. Its activities, while united by a focus on biotechnology research, span multiple scales that range from nanotechnology through the biosphere of land and oceans. The accomplishments of the Task Force include establishment of joint programs that transcend national boundaries and promote open sharing of data and resources. Beyond this, the Task Force has also sponsored scientific discussion among natural and social scientists in

[1] http://ec.europa.eu/research/biotechnology/ec-us/docs/ec-us_tf_decade_of_collaboration.pdf
[2] In general, the hosting county is listed first

diverse areas relevant to biotechnology, including bioethics, the role of women in science, and public perceptions of biotechnology.

The membership of the Task Force comprises representatives from the European Commission and US Government agencies supporting biotechnology research and related activities. With the exception of 2001, the Task Force has met annually since the first meeting in 1990, with the meetings alternating between locations in Europe and the United States. At these meetings, the Task Force members provide updates on the working groups and their activities over the past year. Future activities, including formation of new working groups, as well as proposed courses and workshops, are also discussed. The reports from workshops and meetings are published and are made available on the EC-US Task Force on Biotechnology Research web site[3], which is maintained by the European Commission. The web site provides additional information about the Task Force mission, goals and working groups.

TIMELINE

DATE	EVENT
September 7, 1990	Task Force established
March 1992	Method of Communicating Biotechnology with the Public, Dublin, Eire
October 1992	Biotechnology and Genetic Resources, Airlie, VA, USA
October 1994	Environmental Biotechnology, Brussels, Belgium
September 1995	Neuroinformatics: Workshop on Neuroinformatics, Arlington, VA, USA
June 1996	Renewal of the US-EC Task Force agreement
October 1996	Marine Microorganisms: Research Issues for Biotechnology, Brussels, Belgium
November 1996	Environmental Biotechnology: Workshop on Molecular and Biochemical Bases of Biodegradation, Granada, Spain
September 1997	Workshop on Nanobiotechnology, Arlington, VA USA
December 1997	US-EC Scientific and Technological Cooperation Agreement signed

[3] http://ec.europa.eu/research/biotechnology/ec-us/library_en.html

Summer 1998	Environmental Biotechnology: Theoretical and Practical Course on Molecular Approaches for In Situ Biodegradation. Short Course on Bioremediation, New Brunswick, NJ, USA
June 1998	Immunology and Biotechnology: Workshop on Protection of Newborn and Infants from Infectious diseases, Siena, Italy
September 1998	Farm Animal Genomes, Brussels, Belgium
September 1998	Workshop on the Interoperability of Biological Databases, Hinxton, United Kingdom
September 1999	Workshop on the Use of Molecular Tools in the Study of Ecology and Ecosystem Dynamics, Arlington, VA, USA
September 1999	Workshop on Plant and Animal Bioinformatics, Arlington, VA, USA
October 2000	Tenth Anniversary Meeting of the US-EC Task Force on Biotechnology, Brussels, Belgium
June 2001	Workshop on New Research Tools for a Life Sciences Decade, Valencia, Spain
September 2001	Forecasting the Future of Biotechnology: The Blue Sky Workshop, Washington, DC, USA
March 2003	Environmental Biotechnology: Second Theoretical and Practical Course, Madrid, Spain
April 2003	Workshop on Comparative Research on Biotechnology and the Public, Baltimore, MD, USA
June 2003	Workshop on Biotechnological Approaches to Disease Resistance in Plants and Animals, Washington, DC, USA
December 2003	Workshop on Food Safety Research, Shepherdstown, WV, USA
March 2004	Workshop on Genomics and Environmental Biotechnology, Rockville, MD, USA
April 2004	Workshop on Engineering Plants for Biobased products and Biofuels, Albany, CA, USA
June 2004	Workshop on Origins of Emerging and Re-emerging Diseases in Man and Animals, Brussels, Belgium
January 2005	Workshop on Innovative Technologies for Increasing Food Safety Along the Fork-to-Farm Chain, Brussels, Belgium
March 2005	Workshop on Biobased Product Research, Beltsville, MD, USA
May 2005	Marine Biotechnology Course, Bremen, Germany
June 2005	Workshop on the Future of Plant Biotechnology, Arlington, VA, USA
October 2005	10-Year Anniversary Celebration of the Environmental Biotechnology Working Group, Brussels, Belgium
June 2006	Renewal of the US-EC Task Force Agreement
July 2006	Workshop on the Future of Livestock Genomics, Brussels, Belgium
December 2006	Workshop on Advances in Immunology and Vaccine Discovery, Ames, IA, USA
May 2007	Workshop on Infrastructure Needs of Systems Biology, Boston, MA, USA

May 2007	Second EPOBIO Workshop: Products from Plants - From Crops to Forests to Zero-Waste Biorefinaries, Athens, Greece
June 2007	Symposium on Neuroimaging and its Potential Application to the Study of Food Intake, Oslo, Norway
September 2007	Workshop on Cyber Infrastructure Resources for Genome-Enabled Research on Microbial Life and the Marine Environment, Arlington, VA, USA
February 2008	Workshop on Biotechnology for the Development of Sustainable Bioenergy, San Francisco, CA, USA
April 2008	Workshop on Making in Eating Behavior: Integrating Perspectives from the Individual, Family and Environment, NIH, Bethesda, US
June 2008	Workshop on Nanobiotechnology, Ispra, Italy
June 2008	Workshop on Metabolomics and Environmental Biotechnology, Mallorca, Spain
October 2008	Workshop on Marine Genomics: The Interface of Marine Microbial Ecology and Biotechnological Applications, Principality of Monaco
October 2008	Workshop on Neuroimaging in Obesity Research, NIH, Bethesda, US
May 2009	Workshop on Early Life Programming of Obesity, Noordwijkerhout, NL
May - June 2009	Environmental Biotechnology: Third Theoretical and Practical Short Course, Norman, Oklahoma
June 2009	Workshop on a Global Look at Women's Leadership in Biotechnology Research, San Francisco, CA, USA
November 2009	Workshop on Animal Bioinformatics, Hinxton, United Kingdom
December 2009	Workshop on Plant Bioinformatics, Hinxton, United Kingdom
June 2010	Twentieth Anniversary Meeting of the US-EC Task Force on Biotechnology Research, Barcelona, Spain, “Biotechnology Research for a Complex World”
June 2010	Workshop on Standards in Synthetic Biology, Segovia, Spain

3. ROLE OF THE WORKING GROUPS

The working groups are at the heart of the Task Force's activities and are responsible for identifying topics of mutual interest and organizing workshops that engage scientific experts from the US and European research communities to discuss challenges and opportunities in their respective focus areas. In addition, some working groups organize short courses and short-term exchange programs. Each working group has two Co-chairs drawn from the Task Force membership, one from the US and one from the EC, and in some cases, includes additional Task Force members. For working group activities, additional participants are drawn from the US and European scientific communities, and two scientific Co-chairs are also drawn from this membership. The structure and number of the Working Groups is flexible, allowing new groups to be established as needed while ending those whose work has been completed. These decisions are made after discussion at the annual Task Force meetings. Examples of earlier working groups include those focused on bioinformatics and informatics systems for brain structures and functions. Some of the activities in the area of bioinformatics now cross multiple working groups reflecting the maturation of the research and its relevance across all of biotechnology.

CURRENT WORKING GROUPS

The ***Environmental Biotechnology*** Working Group seeks to bring together senior and early career researchers from both sides of the Atlantic to exchange ideas on using emerging biotechnology capabilities to address environmental problems. This group, which has been in existence since 1994, has sponsored workshops, held summer short courses, and operated short-term exchange programs.

The ***Bio-Based Products and Biofuels*** Working Group focuses on bio-based products and the potential for plants to become an expanded source of industrial feedstocks, reducing dependence on petrochemicals and creating new markets for farmers. This joint Working Group was established in 2004 to facilitate and coordinate research in Europe and the US, combining research training and dissemination of outcomes through workshops and three flagship projects. The activities of this working group provided the foundation for a "science-to-support policy" project entitled "Realising the Economic Potential of Sustainable Resources-Bioproducts from Non-food Crops", or the EPOBIO Initiative, which was funded by the Framework Programme 6 (2002-2006).[4] Within EPOBIO, partners from Europe and the US drawn from academic research institutions and from industry work together with policy makers to assist US and EU decision-making to design a new generation of eco-efficient bio-based products derived from plant raw materials, including second-generation biofuels, bioplastics and green chemicals.

The ***Marine Genomics*** Working Group was established in 1998 to foster European - US collaboration in the field of marine genomics through annual workshops focused on resolving bottlenecks and fostering research in emerging areas of marine ecology and biotechnology.

The ***Plant Biotechnology*** Working Group was established in 2006 to provide a broad vision towards development of coordinated activities in plant genomics and bioinformatics. Its activities to date have been carried out through joint workshops.

The ***Farm Animal Genomics*** Working Group was established in 1998 to capitalize on the discoveries emerging from human and vertebrate model genome sequences. It has operated through joint workshops.

[4] http://epobio.net

The accomplishments of these working groups over the past decade are highlighted in the following chapters.

3. LEADERSHIP IN BIOINFORMATICS

The Task Force recognized early on that management and analysis of biological data and information would be critical for successful collaboration and future progress. The origins of the data and information have always been diverse, from environmental to molecular, in keeping with the breadth of the Task Force's activities.

In its first year, the Task Force discussed databases and noted the need for them in a variety of areas, including plant pathology, vaccines and soil microbiology. The following year, the Task Force heard proposals for US-European databases on biosafety, genomes and sequences, taxonomy and genetic resources that covered genome analysis, environmental performance and genetic diversity. These discussions led to a workshop on Biotechnology and Genetic Resources, held at Airlie House, VA, from which the concept of the Global Biodiversity Information Facility, or "GBIF", emerged[5,6]. The GBIF database was established in 2001 to enable free and open access to information about all known living species.

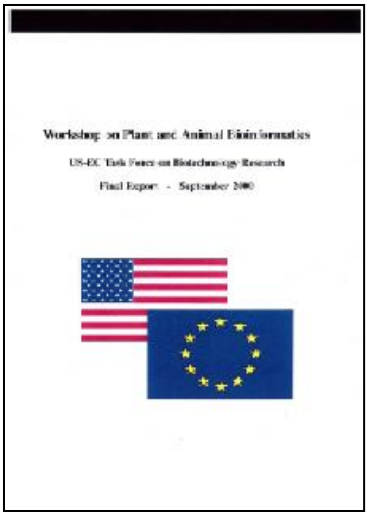
An EC - US Workshop held in 1995 led to the establishment of a steering group in 1997 on Neuroinformatics. The activities of the steering group contributed to the formation of the Organization for Economic Cooperation and Development (OECD) megascience working group and the launching of the International Neuroinformatics Coordinating Facility in Stockholm in 2007.

The importance of standards to the success of future database efforts was recognized by the Task Force and a workshop was held on Standards in Bioinformatics in Hinxton, United Kingdom, in September 1998. At that

[5] http://ec.europa.eu/research/biotechnology/ec-us/workshop_1092_en.html
[6] http://www.gbif.org/

time, many databases focused on specific content were springing up around specific data sets and data types. This workshop turned the focus towards the databases themselves, recognizing that interoperability would be fostered by a discussion across different research fields. It was followed by a workshop on Plant and Animal Bioinformatics in Arlington, VA, in September 1999 that emphasized the importance of bilateral cooperation in such areas as tool development, data release, and training.

The rapid expansion of the internet and advances in genomic technologies has only served to increase the need for integration of bioinformatics into all working group activities. It has been a recurring theme throughout the training courses and workshops held over the past decade and is again at the forefront as next-generation sequencing technologies have made it possible to generate large amounts of data at low cost. However, this technological advance brings new challenges for data analysis and integration that will likely occupy the Task Force for some time to come. It is notable that in the past three years, three of its workshops have focused specifically on cyberinfrastructure, database and informatics needs in plant biotechnology, marine genomics and farm animal genomics.



4. ENVIRONMENTAL BIOTECHNOLOGY

Environmental Biotechnology is an exciting area of science for US-European collaborative activities. Both the US and Europe share the need for cost-effective solutions to environmental problems such as contamination in soils and subsurface environments, degradation of the quality of lakes and rivers, and the need for more green technologies for waste management. At the same time, both the US and Europe have a scientific workforce that is trained in the disciplines of importance to environmental biotechnology: microbiology, molecular biology, microbial ecology, biochemistry, computational bioscience, and environmental engineering. Through the Working Group on Environmental Biotechnology, the US-EC Task Force has created a forum for scientists to engage in high level discussions and scientific exchange on this topic of mutual interest and to capitalize on shared knowledge. Moreover, the Working Group has also served as a catalyst for growing the next generation of scientific leaders through its training activities for young scientists on both sides of the Atlantic. One of the measures of success of the Working Group is that three of its current members, now scientific leaders in their own right, were trained through Working Group activities.

FORMATION OF THE WORKING GROUP ON ENVIRONMENTAL BIOTECHNOLOGY

The EC-US Working Group on Environmental Biotechnology was initiated with a workshop in Brussels, in October 1994. The participants clearly saw the enormous potential and future benefits of collaborative activities in this globally important area of research. The workshop attendees recommended that the Task Force establish a Working Group to foster interactions between

the US and European countries in environmental biotechnology. The idea was met with great enthusiasm by the Task Force, and Dr. Ioannis Economidis of the European Commission and Dr. Anna Palmisano, then at the US Office of Naval Research, were asked to co-chair this effort. Working Group members were identified who were internationally recognized leaders in the field from across the US and from EU member countries.

The organizational meeting of the Working Group took place at the July 1995 Gordon Conference on Applied and Environmental Microbiology in New Hampshire. At that seminal meeting, the Working Group articulated its mission: "To train the next generation of leaders in environmental biotechnology in the United States and the European Union to work collaboratively across the Atlantic." The philosophy was that, if collaborations can be started early in a scientific career, they can last a lifetime.

Since 1995, the Working Group has succeeded in training hundreds of early career scientists to achieve this goal. The Working Group has defined early career scientists as those that are finishing their doctoral work, engaging in post-doctoral research, or beginning a new position in a tenure track or its equivalent. The Working Group proposed and has now supported for 15 years three types of activities:

- Workshops on the use of molecular methods and genomics in environmental biotechnology;
- Short courses with theoretical, laboratory and field elements; and,

- Short-term exchange fellowships. The short term exchange fellowships were created to enable young scientists to develop collaborations with colleagues across the Atlantic and to learn a new skill or expertise in the area of environmental biotechnology.

WORKSHOPS

The first Working Group activity was to sponsor a workshop on the

Molecular and Biochemical Bases of Biodegradation in Granada, Spain in November 1996. The Workshop was led by Dr. Juan Ramos of the Consejo Superior de Investigaciones Cientificas (CSIC) in Granada. To engage young scientists, the Working Group proposed an innovative format that has since been replicated in all Working Group-sponsored workshops. Twenty scientific leaders (ten from each side of the Atlantic) were invited to attend. Then, each of the scientific leaders was asked to identify the most promising young scientist in their area of expertise, and that person was also invited. Thus, the attendees came as pairs of senior and early career scientists. The resulting dynamic was that the early career scientists came to the workshop with a senior mentor, and they felt fully empowered to engage in scientific dialogue and to build an international network of colleagues from the community of environmental biotechnology.

In March 2004, a workshop on “Genomics and Environmental Biotechnology” was held at the The Institute for Genome Research (TIGR) in Rockville, Maryland. The goal of the workshop was to examine the role of genome science in environmental biotechnology. The format was similar to the highly successful workshop in Granada, with senior scientists being accompanied by promising early career scientists. The

meeting was organized by Dr. Barbara Methe of TIGR as the lead organizer; as an early career scientist, Dr. Methe had been a participant in a Working Group sponsored Short Course. The workshop covered topics ranging from molecular studies of marine biogeochemical cycles, to gene transfer in hyperthermophiles, and novel genome annotation tools. Attendees concluded that there was an enormous potential for genome science to advance a wide range of research in environmental biotechnology.

More recently, the Working Group on Environmental Biotechnology organized a workshop on the use of metabolomics to advance the science of environmental biotechnology. The joint EC-US workshop, entitled “Metabolomics and Environmental Biotechnology,” was held in Mallorca, Spain, from June 16-17, 2008. Dr. Balbina Nogales, from the Universitat de les Illes Balears, was the organizer; she too was a participant in previous Working Group activities. The workshop brought together internationally-renowned senior scientists as well as 20 promising young scientists identified by the senior scientist participants. The workshop covered topics on metabolomics and functional analysis of microbial communities. A vast amount of information on the (meta)genomes of microorganisms is being generated at a rapid pace. The potential exploitation of these discoveries in environmental biotechnology is enormous, but requires profound knowledge of the functioning of microbial cells as complex networks of interacting metabolites. The potential of such metabolomic studies for environmental biotechnology - such as the development of novel biocatalysts, novel

biomarkers or more efficient and safer processes - was the topic of discussion.

SHORT COURSES

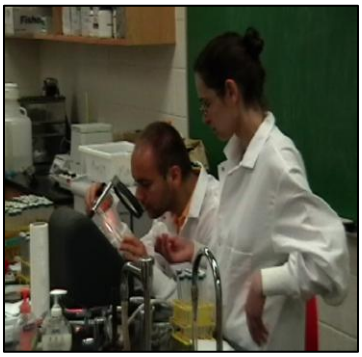
In June 1998, the Working Group sponsored its first short course for training early career scientists from Europe and the US in environmental biotechnology. The course was designed to give students hands-on experience with the latest methods in environmental biotechnology; the format combined lectures, laboratory research, and field work. Twenty four graduate and post-graduate students, drawn from 12 States in the US and eight countries in the EU, worked side by side in the laboratory and in the field collecting samples from a nearby industrial site contaminated by fuels. The students learned the latest methods in molecular biology to characterize the microorganisms and genes involved in biodegradation of hydrocarbons.

The success of the Rutgers Short Course led to development of a US-EC short course in the EU. Drs. Victor de Lorenzo and Juan Ramos of CSIC led a two-week class in Madrid in March 2002. The course theme was "Molecular Biology for the Environment." Students were early career scientists drawn from throughout the US and EU. The course attracted leading researchers in the field, both from the EU and US, as lecturers, and a stellar group of 24 young scientists as participants. Over 160 students competed for 12 US and 12 EU slots. The students participated in laboratory and field experiments ranging from the latest methods in modern molecular biology to collection of samples at the site of a recent oil tanker spill on Spain's Northern Coast.

More recently, a short course for early career scientists in Europe and the US was held at the University of Oklahoma in May-June 2009. Dr. Joseph Suflita was the lead organizer for this short course, which was modeled on the previous, highly successful short courses held at Rutgers University in 1998 and the University of Madrid in 2003. Again, participants and guest lecturers were drawn, in equal number, from both the US and EU nations. Twenty-four students received training in cutting-edge techniques in molecular biology and participated in field-related research at a nearby landfill. This course had a cross-cutting theme of anaerobic microbiology - the study of microbes that thrive in the absence of air. Topics included advanced culturing techniques, molecular profiling of microbial populations, environmental metabolomics, sequencing and functional analysis, as well as bioinformatics.

EXCHANGE FELLOWSHIPS

In 2000, the Working Group began a new effort centered on short-term exchange fellowships for early career scientists. The idea was for young scientists to have the ability to learn a new skill or expertise in environmental biotechnology through a trans-Atlantic exchange fellowship. The fellowships were from one to six months in length, and required leveraging of costs from both the host and parent institutions. The US effort was led by Drs. Judy Wall and Joe Suflita. Dr. Spiros Agathos led the EU effort. Applicants represented a cross-section of EU countries; nine EU fellows from six Member States have been supported to date to work in US labs. Fellows engaged in research ranging from genomics to microbial ecology to bioremediation research. To date, 18 US fellows have been supported to work in laboratories in seven EU countries.



LOOKING AHEAD

In October 2005, the Working Group celebrated its first decade of activities to foster scientific exchange in environmental biotechnology between Europe and the US. It was very satisfying to the Working Group to bring together a subset of the many students and young scientists that have been trained over the years. The young scientists shared with the Working Group the many ways that the activities had impacted their careers through expanding their scientific horizons and developing new trans-Atlantic collaborative activities, colleagues and friends.

Now, after fifteen years of success, the Working Group has spent time reflecting on its approaches and ways to continue to introduce new and innovative approaches to enhance collaborative activities for early career scientists. The Co-Chairs are greatly indebted to the unflagging commitment and dedication of the members of the Working Group, whose members are listed below. Their enthusiasm, energy, creativity and hard work were inspiring. The Working Group plans to build on its successes with two upcoming activities in 2011: a short course to be held in Switzerland and a workshop on “Microbial Communities and their Interactions” to be held in St. Louis. New activities will include time for mentoring or “coaching” sessions for the young scientists on career planning.

WORKING GROUP ON ENVIRONMENTAL BIOTECHNOLOGY

Anna Palmisano US Co-chair	Ioannis Economidis EC Co-chair
Dept. of Energy Office of Science	European Commission Research Directorate

WORKING GROUP MEMBERS (1995 - 2010 INCLUSIVE)

Spiros Agathos – EU
Kelly Bender - US
Dick Janssen - EU
Jerry Kukor - US
Jan van der Meer -EU
Barbara Methe - US
Ivonne Nijenjhuis -EU
Balbina Nogales - EU
Juan Ramos -EU
Joe Suflita - US
Judy Wall – US
Peter Williams - EU
Lily Young - US
Gerben Zylstra - US

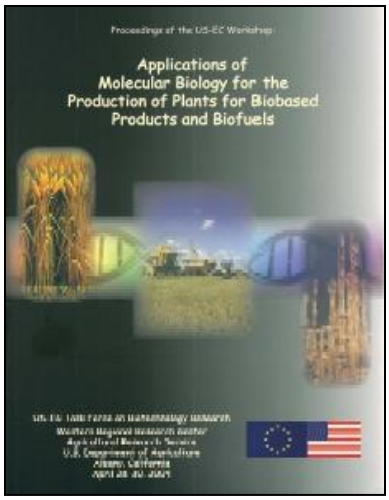
WORKING GROUP ADVISOR

Victor de Lorenzo - EU

5. BIOENERGY AND BIOBASED PRODUCTS

The biotechnology revolution of the last 25 years offers great promise for solving many of the scientific and technical challenges associated with the development of biobased products and of bioenergy and biofuels as large-scale, sustainable options versus fossil-based products, energy systems and transportation fuels. Building on advances in DNA technologies resulting from the Human Genome Project, new systems biology research programs are being developed internationally that are creating a new generation of biological research. These new research approaches involve the bringing together of scientists from diverse fields to understand the complex biology underlying solutions to the challenges of bioenergy and biobased products. New interdisciplinary research communities are being created, as are knowledge bases and scientific and computational resources critical to advancing large-scale, genome-based biology.

In April 2004, an EC-US Workshop on “Applications of Molecular Biology for the Production of Plants for Biobased Products and Bioenergy” was held at the US Department of Agriculture (USDA)-Agricultural Research Service (ARS) Western Regional Research Center, Albany, CA, USA. Participants agreed to identify one or more flagship projects and to make communication and personnel exchange between European and US scientists a priority. Follow-up activities from that workshop led to the development of “flagship” projects for plant cell walls, plant oils, and biopolymers.



Subsequently, an international project, EPOBIO, was supported through the European Union's 6th Framework Research Programme with the participation of the USDA-ARS, which built on the work of the Biobased products Working Group of the EC-US Taskforce on Biotechnology Research. The funded projects: (i) RENEWALL – "Improving Plant Cell Walls for Use as a Renewable Industrial Feedstock", (ii) ICON – "Industrial Crops Producing Added Value Oils for Novel Chemicals" and (iii) EU-PEARLS – "EU-Based Production and Exploitation of Alternative Rubber and Latex Sources" are being financed through the European Union's 7th Framework Research Programme, with a total EC contribution for the three exceeding 17 M€.

Partners from the US are involved in all of these projects, with a total number of seven partners. Benefits of the EPOBIO program and contributing programs from the USDA, US Department of Energy (DOE), and National Science Foundation have advanced a biobased economy for both the EU and the US. This work was coordinated by Dr. Antoinette Betschart and Dr. Judy St John (US) and Dr. Laurent Bochereau and Dr. Piero Venturi (EC). This support is funding pioneering research aimed at understanding the genetics, genomics and chemistry of cell walls and cell wall biosynthesis. New strategies are being developed for gene discovery of novel hydrolases and their targeting to key components of the cell wall.

Projects funded following the 2004 Workshop are also providing pioneering research in the development of new ligno-cellulosic feedstocks for bioenergy. Plant oils are being investigated as a sustainable alternative for the use of fossil fuels including progress in discovery of the genes, pathways and regulatory processes governing the synthesis of wax ester species. Biopolymer research aims at acquiring a better understanding of the genes and metabolic processes involved in rubber production and in the development of alternative rubber crops.

Only three years ago, during the Plenary Session of the EC-US Task Force in July 2007, under the co-chairmanship of Dr. Kathie L. Olsen, Deputy Director, NSF and Mr. Christian Patermann, Director for Biotechnology, Agriculture and Food, DG Research, European Commission, a Workshop on Biotechnology for Sustainable Bioenergy was proposed. The workshop included new bioenergy technologies and new institutions such as the new DOE Bioenergy Centers in the US and other newly established projects in Europe and the US. The coordinators of the activity were Drs. David Thomassen (DOE), Kay Simmons (USDA), Maria Fernandez Gutierrez (EC), and Maurice Lex (EC).

The workshop explored the potential of biomass to serve as a versatile renewable energy source. Indeed, while other renewable sources can be used for the production of heat and electricity, biomass is the only renewable source that can also be converted into a transportation fuel that is compatible with existing infrastructure. Furthermore, biomass is a renewable raw material for the production of bioproducts such as chemicals and materials.

BIOLOGICAL RESEARCH IS THE KEY TO DEVELOPING NEW AND EXPANDED FEEDSTOCKS:

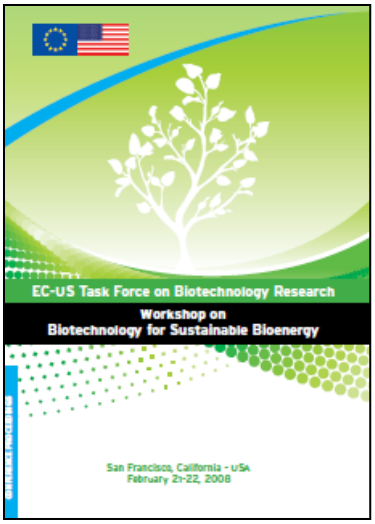
- It can contribute to accelerating the deconstruction of cellulosic biomass into sugars that can be converted to biofuels. The production of biofuels from cellulosic biomass offers not only greater potential in terms of expanding the feedstock base but also results in improved energy and environmental performance.

- It can assist in the development of other promising alternatives, both in terms of feedstock and end-product such as Aquatic biomass. Algae do not compete with arable land for food production

and can be used for the production of a variety of products, ranging from cosmetics and biodiesel to hydrogen.

On a longer term perspective, the production of hydrogen directly from solar energy and water by means of an artificial photosynthesis could provide an almost unlimited source of energy. One scientific approach that has been explored is to study and learn from natural processes and to develop chemistry where the key reactions from nature are mimicked but not directly copied. The latest advances in biotechnology make use of synthetic biology for the possible modification of organisms or components from organisms - even designing them from scratch - to produce tailor-made biofuels with optimal energy content and blending potential with gasoline.

The US-EC Workshop on Biotechnology for Sustainable Bioenergy held in San Francisco, California, February 21-22, 2008, focused on three key challenges facing the growth and development of bioenergy as a sustainable alternative to today's reliance on petroleum-based liquid transportation fuels: (1) bioenergy feedstocks, (2) advanced biotechnologies for biomass-to-bioenergy, and (3) socio-economic and environmental challenges. The participants discussed scientific challenges, research priorities and knowledge gaps, recommendations for biotechnology research, and opportunities for US-EC collaboration.



The workshop identified a number of challenges and opportunities that need to be addressed in the coming years in relation to the development of bioenergy as a sustainable international commodity. Many of the

recommendations from the 2008 Bioenergy Workshop are still high priorities.

ONGOING SCIENTIFIC CHALLENGES

- There is a need to develop a fundamental understanding of plant cell wall synthesis, morphology, physiology and composition, as well as strategies for their modification, maximizing yields, and adapting bioenergy crops for use in diverse environments.

- Maximizing the benefits of intellectual property while minimizing its impact on research collaboration.

- Scaling developments and technologies made in the laboratory to demonstration and production scales.

- Maximizing benefits of biotechnology and sustainable bioenergy development while minimizing impacts on communities, environments, and resources.

The identification of research priorities and knowledge gaps needed to address these scientific challenges resulted in a range of recommendations for both biotechnology research and opportunities for US-EC collaboration, including:

RESEARCH

- New resources, tools, and interdisciplinary interactions are needed for the development and characterization of next generation biomass crops. This includes more emphasis on the development of unified methodologies that focus on Life Cycle Analysis (LCA)

and sustainability. An LCA is needed both for economic and for environmental considerations.

- Standards and benchmarks are needed to improve technologies and processes for biomass conversion to biofuels.
- We need a greater focus on agricultural practices, including development of bioenergy crops and farming practices that minimize competition with food crops (including use of marginal lands), use of resources such as water, and inputs such as fertilizers.

COLLABORATION

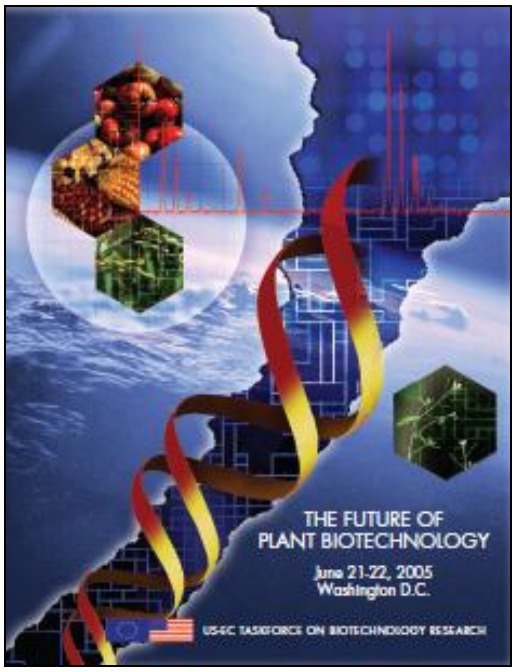
- Exchange and training of students, postdoctoral fellows, and staff.
- Development of topically focused summer schools for students and postdoctoral fellows.
- Development of joint, standardized methods for life cycle analysis.

The opportunities for and the potential benefits of continued Europe-US collaboration to address the scientific challenges of biobased products and bioenergy are great and hold the promise for dramatic scientific breakthroughs in our understanding of biological systems and for great payoffs for society and the environment.

6. PLANT BIOTECHNOLOGY

The Plant Biotechnology Working Group is the newest working group, having been established in 2006 to develop joint research cooperation between the US and the EU in the broader area of molecular plant sciences and biotechnology.

Prior to the creation of this Working Group, two Task Force events had already addressed plant research, including the workshops on "Plant and Animal Bioinformatics" (Arlington, VA, 1999) and "Biotechnological Approaches to Disease Resistance in Plants and Animals" (Washington, DC, 2003). However, it was at the Conference on the "Future of Plant Biotechnology" which was held in Arlington in 2003 that a concrete recommendation was made by the scientific experts to establish a dedicated forum for discussion of transatlantic cooperation on plant genomics and biotechnology. The experts considered that the time was ripe to develop a common vision for plant sciences for the next 10 - 20 years, building on the impressive advances in genomic and post-genomic sciences. While highlighting the different approaches to research funding in the EU and US (for example, more fundamental work on Arabidopsis *versus* research in various crops), they concluded that fundamental and applied approaches could complement one other and be an asset for setting up joint activities.



Some concrete ideas for the working group's activities included:

- Holding regular (yearly) exchanges of information regarding new areas identified for research funding in the US and Europe, to identify commonalities and complementarities
- Promotion of US-European collaborations on large-scale projects such as genome sequencing, functional genomics, or data integration
- Promotion of joint calls for proposals (e.g., the joint NSF-DFG Arabidopsis program or international, interdisciplinary training programs of graduate students and postdoctoral researchers)
- Bridging of the gap between US and EC programs in plant biotechnology

MEMBERSHIP AND MODUS OPERANDI

The Plant Biotechnology working group is composed of a core group of 2-4 scientists from each of the US and EU communities plus representatives from the research funding organizations (US National Science Foundation and the Research Directorate General of the European Commission) who serve as Co-chairs. The group represents wide expertise in plant biology and bioinformatics to ensure that a broad view is taken of the current and future challenges in this area. Depending on the specific topics under consideration, additional experts are invited to contribute to discussions, events and publications.

In general, meetings and/or specific events are held once a year and alternate between a location in the US and the EU, ideally taking advantage of international scientific conferences. In addition, representatives of the funding bodies attend the annual Task Force meetings to report back to the other working groups to ensure that

synergies are enabled across on-going activities. Regular, video and telephone conferences have also proven to be efficient means of communication allowing for continuous update and exchanges.

ACTIVITIES

Since its creation in 2006 the EC-US Plant Biotechnology Working Group has held two scientific meetings and organized a workshop on plant bioinformatics.

First Meeting, Brussels, February 2007

The first meeting served to launch discussions on the scope and the priorities for possible collaborations between US and EC research groups to advance the field of plant biology and plant biotechnology. Discussions took place in form of lively brainstorming which resulted in an "Action Plan" including:

- Recommendations on mechanisms for implementation of research cooperation (e.g., joint calls and coordination of existing programs and efforts)
- Identification and priority listing of "big scientific questions in plant biology"
- Important applications for biotechnology
- The need for essential infrastructures, enabling techniques and resources as a pre-requisite for basic and translational research. Cyberinfrastructures and stock centers for plant research were considered top priorities[7].

[7] The report can be accessed through http://ec.europa.eu/research/biotechnology/ec-us/index_en.html.

Second Meeting, San Diego, January 2008

Building on the results of the first meeting, the second working session of the group was intended to narrow down the suggestions for research areas and within each area to specify one or more coordinated activities or projects that could be implemented in the short-term. Besides scientific considerations, It was agreed that the US-EU activities and projects selected should:

- represent flagship areas of common interest to the US and EU
- represent common challenges
- involve activities that both sides need that neither could do alone
- benefit from synergies and generate added value

The meeting benefited from the presence of invited EU and US experts that were already involved in transnational collaborations, in particular in the context of major sequencing initiatives:

- Catherine Feuillet (INRA Clermont-Ferrand) representing the EU project "Triticeae Genome" and the International Wheat Genome Sequencing Consortium;
- Willem Stiekema (Wageningen University) representing the EU funded "EU-SOL" project and the International Solanaceae Sequencing Initiative;
- Jim Giovannoni (USDA-ARS and Boyce Thompson Institute, Cornell University) representing the International Solanaceae Sequencing Initiative.

The invited experts provided examples of "big" initiatives for which they saw a clear need for joint US-EU funding and for sharing technological,

genetic and genomic resources in order to reach objectives faster, more efficiently and more cost effectively.

This meeting resulted in a working document in which the group gathered the individual suggestions for research topics and proposed as a theme for EU-US research collaboration: “Building translational pipelines for plant biotechnology encompassing food, feed, and renewable resource development (including energy)". These translational pipelines would include technology platforms directed toward specific applications including abiotic stress tolerance and gene-based plant breeding. The group also reiterated its view that collaboration on cyberinfrastructures is essential to respond to the need for handling sequence or phenotypic data as well as for establishing standards for data integration, storage and visualization.

Finally, education, training, mobility of researchers and outreach activities were considered as important areas which would particularly benefit from increased funding and collaboration and which could be implemented at a short term[8].

US-EU Workshop on Plant Bioinformatics, Hinxton, December 2010

Following up on the suggestions emerging from the previous two meetings, the Working Group organized its first specialized workshop in the area of plant bioinformatics. The workshop was held at the Wellcome Trust Conference Centre next to the genome

[8] The document can be accessed through http://ec.europa.eu/research/biotechnology/ec-us/index_en.html.

campus in Hinxton, United Kingdom.

The workshop was chaired by Drs. Doreen Ware (USDA-ARS and Cold Spring Harbor Laboratory, NY) and Klaus Mayer (MIPS) and attended by about 35 scientists (almost equally distributed between the US and EU), representatives of funding bodies (US, EC, Germany, and the UK) and observers from a recently-held Task Force Workshop on animal bioinformatics. Expertise-wise, the event brought together plant scientists, bioinformaticians and managers of major data resource centers and thus allowed for fruitful exchanges between the various communities generating, processing, using and making the information widely accessible. The workshop program was organized around general and break-out sessions, including the following topics:

- Plant Bioinformatics: Next Generation Needs
- Cyberinfrastructure
- Sequencing
- Databases
- Phenotyping and Ontology
- Data integration
- Data Analysis
- Next Generation Bioinformatics Education

The participants highlighted the major trends driving biology needs and technology development and from there identified a few principles that could be used to guide the short and medium-term future of database development and data integration. Overall, the capacity of data infrastructures and their ability to integrate unprecedented amounts of genomic information from various sources and at various levels were

considered to become the major challenge in view of unlocking the full potential of genomics to advance plant sciences and plant improvement.

The workshop discussions and conclusions are summarized in a document which is intended to serve as a "White Paper" outlining short and medium-term visions for international collaboration on database resources and infrastructures. The document will be officially presented on the occasion of the 20th Anniversary Meeting of the EC-US Biotechnology Task Force (Barcelona, June 2010) and it is hoped that the findings and recommendations can be also used by other Task Force Working Groups, such as the ones on Farm Animal Genomics or on Marine Biotechnology.

NEXT STEPS

Despite being a "young" working group, the Plant Biotechnology working group has already proven its value, increasing the visibility of plant sciences and biotechnology within the overall Task Force and providing input to related working groups. The practical advice and the vision for the future of plant research will be pursued over the coming years. The Working Group particularly seeks to make use of the various mechanisms proposed to implement and intensify EU-US research. For the next future (2010-2012) initiatives, training and staff exchanges are envisaged. Also, the joint funding of research projects will receive special attention. This area will require particular political commitment and efforts to be able to bridge the different modalities of project selection and funding procedures in the US and Europe. The Working Group is grateful for the high level of commitment shown by the scientists participating in the various events, thereby contributing to creating a dynamic platform for transatlantic collaboration on plant research. It owes particular thanks to the Co-chairs of meetings and workshops who were instrumental in turning ideas into successful events.

WORKING GROUP ON PLANT BIOTECHNOLOGY

CO-CHAIRS (2006-2008)

Machi Dilworth
National Science Foundation

Guillermo Cardon
European Commission
Research Directorate General

CO-CHAIRS (2008 – PRESENT)

Jane Silverthorne
National Science Foundation

Annette Schneegans
European Commission
Research Directorate General

TASK FORCE MEMBER

Tomasz Calikowski
European Commission
Research Directorate General

SCIENTISTS (2006-PRESENT)

Natasha Raikhel*
University of California, Riverside

Marc Zabeau*
Ghent University

Steven Briggs*
University of California, San Diego

Thomas Altmann
Max-Planck-Institute & Potsdam University

Doreen Ware*
Agricultural Research Service
US Department of Agriculture &
Cold Spring Harbor Laboratory

Klaus Mayer*
Helmholz-Zentrum Munich

Maureen Hanson
Cornell University

Ottoline Leyser
York University

*served as scientific Co-chair

7. MARINE GENOMICS

The ocean claims over 70% of the Earth's surface and about 3.5 billion years ago was probably the birthplace of life. Marine microbes number in the millions in a single teaspoonful of water yet, until recently, these microorganisms have been overlooked and undervalued. Recent advances in DNA technologies and heightened awareness of environmental issues, such as global warming, have come together to catalyze the science of marine microbiology. Millions of microbial species, as consumers and producers of major greenhouse gases are key players in the impacts of global climate change. For example, marine microorganisms account for 50-90% of global primary production and microbial phytoplankton growth rates, size, shape and sinking rates influence the biological carbon pump, the process which removes carbon from the atmosphere and the upper ocean and transports it to the deep sea. One estimate has suggested that the oceans are the largest reservoir of microbes on Earth with approx. 10^{28} in the Global Ocean. We are just beginning to appreciate the pivotal roles these microbes play in the health of the marine ecosystem and, by extension, the planet.

The field of marine microbial science is little more than 30 years old and the field of marine genomics less than a decade. Early breakthroughs in understanding the vast diversity and metabolic capabilities of marine microbes were first achieved with the use of molecular and genetic tools. This is because microbial biodiversity is captured in their genomes and not in their morphologies, as we typically think of with plants and animals. This point cannot be overemphasized as the lack of distinct morphological characteristics in microbes belied their true diversity and prejudiced our early view of microbial diversity in the Tree of Life. Within the last decade, sophisticated molecular studies revealed that microbial communities in the ocean are immensely diverse and possessed new, novel and frequently

unexpected mechanisms for energy generation. The recent discovery of an abundant and diverse mix of viruses has forever altered our understanding of the marine food web. Perhaps most importantly, they appear to be at the nexus of a global gene pool which drives the evolution of microorganisms. Many marine animals, such as clams, shrimp and fish are host to a diversity of microbes, their so-called "microbiome" and in many cases, these benign microbes can be more abundant than their host cell types. These associated microbes play an integral role in the health and fitness of the host by influencing host development, nutrition and disease resistance. We are just beginning to understand the evolutionary and ecological significance of these intimate animal-microbe relationships.

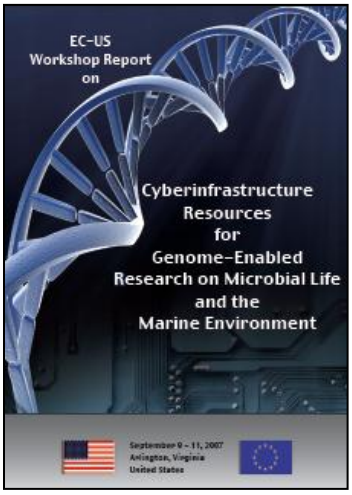
THE ORIGINS OF THE WORKING GROUP FOR MARINE GENOMICS

The power of DNA sequencing methods to provide a "parts list" for individual microbial species (genomics) or a community of microbial species (metagenomics) has transformed the nature of marine microbiology. In response to the increasing visibility of marine microbiology and marine genomics, a community-driven workshop on "Genomic Approaches for Studying the Marine Environment and Resources" was held at the Max Planck Institute (MPI) for Marine Microbiology in Bremen, Germany in 2005 from which the Working Group for Marine Genomics would eventually be born. The goal of the meeting was to explore common interests in the field of marine genomics and to develop recommendations for their implementation. The organizers were Dr. Mary Ann Moran of the University of Georgia, USA, Dr. Rudolf Amann of the MPI for Marine Microbiology, Germany and Dr. Catherine Boyne of the CNRS Biological Station, Roscoff, France. Over 20 scientists from the US, European Union and Iceland participated in the workshop which recommended that significant US-EC coordination of large-scale projects would be required to fully exploit the potential of genome sequence analysis, gene expression analysis and bioinformatics tools. The second

key recommendation was the creation of the Working Group, a suggestion subsequently ratified by the US-EC Joint Task Force later in 2005.

The Working Group was established by Dr. Maryanna Henkart, US National Science Foundation, Arlington, VA and Dr. Maurice Lex, EC Research Directorate General, EU Brussels. This is one of the youngest working groups in the Joint Task Force and its goal is to foster transatlantic collaborations in marine genomic science, highlight knowledge gaps in the field ripe for future effort and identify opportunities for young investigators in marine genomics. Dr. Lita Proctor, US National Science Foundation, succeeded Dr. Henkart, who retired in 2008. Dr. Garbiñe Guiu, EC Research Directorate General, EU Brussels, succeeded Dr. Lex, who retired in 2009. Two international US-EC workshops in Marine Genomics have been held to date.

ACTIVITIES OF THE WORKING GROUP



The first workshop was held at the National Science Foundation headquarters in Arlington, VA in 2007, focusing on “Cyberinfrastructure Resources for Genome-Enabled Research on Microbial Life and the Marine Environment”. Like the original meeting, this workshop was also organized by Drs. Moran and Amann, who remained as science co-chairs for the group. The workshop included over 20 scientists from several countries in the European Union as well as the United States. Recommendations from this workshop included the compelling need for an international coordinated ecological genomics cyberinfrastructure and a call for a joint US-EC training course in environmental bioinformatics.

The second workshop entitled, “Joint EC-US and Mediterranean Marine Science Consortium (CSIEM) Workshop on Marine Genomics: At the interface of Marine Microbial Ecology and Biotechnological Applications” was held in Monaco in 2008. By this stage the Working Group had two new science Co-chairs, Dr. Douglas Bartlett of the University of California at San Diego, California, USA and Dr. Frank Oliver Glöckner of the Max Planck Institute for Marine Microbiology, who took the lead in organizing the meeting. The workshop was attended by over 30 scientists from the EU, the US and northern Africa, including Egypt, Morocco and Tunisia, reflecting the importance of the Mediterranean Sea. Key recommendations from this workshop included the need for metagenomic science to address fundamental questions in microbial ecology and the need for a continued effort to reduce the bioinformatics bottleneck – swamped by the delivery of data – in both genomics and metagenomic science. The meeting reiterated the need for a joint training course in bioinformatics.

The next workshop will take place once again in Washington DC in October 2010 and is also being planned by Drs. Bartlett and Glöckner. It will address the impact and contribution of so-called “next generation” sequencing technologies on marine genomic and metagenomic science. A unique feature of this workshop will be a round table discussion between scientists and industry representatives of the new technologies in DNA sequencing. The Working Group, while relatively new, is already informing the development of research funding in Europe and in the US. Bioinformatics expertise is a pressing need to comprehensive investigations of microbial science in the marine environment and the repeated calls for joint training in bioinformatics should come to fruition in the near future.

8. FARM ANIMAL GENOMICS

The Farm Animal Genomes workshop in Brussels in 1998 was the initial activity of the "Farm Animal Genomics Working Group" of the EC-US Task Force on Biotechnology. Fostering and encouraging cooperation in the mapping of genomes of farm animals, this Working Group has been active since the 1998 workshop. In the 10th anniversary report of the Task Force, the Farm Animal Genomics Working Group reflected on the completion of the human genome sequence. Since that time, the science of genome sequencing has developed beyond imagination, and at least 25 animals have had their genomes sequenced. These include species of great agricultural importance such as the cow, chicken, horse, pig and others, with a number of projects on-going.

Our understanding and appreciation of the value of genomics and the utility of a ‘reference’ sequence and the need for re-sequencing continues to evolve as the genomics landscape grows with increasing speed, and with reduced costs of generating sequence data. In addition to progress in DNA sequencing and gene annotation, progress has been made in understanding the complexity of gene expression and regulation (microRNA, copy number variation, insertions and deletions). The buildup in data storage and need for data analysis tools are breathtaking. Storing, curating and retrieving the structured information resulting from genomic studies are great challenges, just beginning to be met.

The promise of these new tools is to provide fresh perspective and improved biological understanding at the cell, tissue, individual, and population levels. From this point of view, agricultural animals can play an important role in comparative genomics vis-à-vis the human species. The ability to make desired crosses and test hypotheses requiring specific matings among animals with well known pedigrees and well defined

phenotypes is an important tool for agriculture. Furthermore, illuminating the effects of selection on gene frequencies and whole physiological pathways has already yielded insights on the relative importance of genes and their expression, and agricultural animal genomes serve also as models for the human genome. For example the genes and organization of genes involved in lactation in cows provides a closer model to human lactation than typical rodent models. From the agriculture perspective, whole genome selection (already initiated in dairy cattle) will also enable progress even on poorly heritable traits.

Over the last ten years the Farm Animal Genomics Working Group has contributed and helped scientists keep pace through funding and sponsoring a series of scientific workshops focused in 2 main directions: genomics and animal health. On the genomics front, in 2006, a workshop on the Future of Livestock Genomics was held in Brussels, followed by the recent Farm Animal Bioinformatics workshop in November 2009 held in Cambridge/Cambourne U.K (an earlier workshop on plant and animal bioinformatics had been held in 2000 in Arlington, Virginia, USA). The EC-US Task Force workshops have provided venues leading to the formation of international consortia for sequencing various animal genomes, including chicken, bovine, and swine. In addition, following the 2006 workshop entitled, “The Future of Livestock Genomics”, transatlantic collaborations on whole genome selection were initiated.

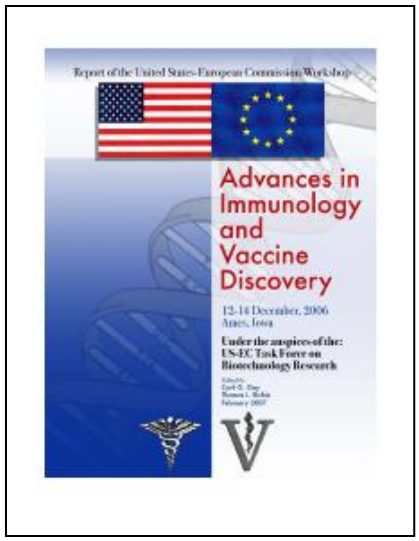
The recent workshop on bioinformatics further drew attention to the importance of reference animal populations, the paucity of animal bioinformatics applications and tools, and the need for data repositories with common/compatible standards. Each (large) research project should have appropriate resources for bioinformatics including plans for making data available and accessible, genome annotation. The need to focus on

training in bioinformatics and training the next generation of scientists with a passion for agriculture was expressed clearly in this workshop.

On animal health, two workshops have been organized with regard to infectious diseases. The first workshop "Emerging Infectious Diseases" was held in Brussels, Belgium, June 21-22, 2004. The timing of the workshop coincided with the stage of the SARS epidemic when it was coming under control, after cases of monkey pox had been declared in the USA, and when the H5N1 avian influenza had recently spread with an alarming speed across the world. The workshop gathered scientists from different backgrounds working on human and animal diseases and was structured around the following questions: *What is going on with infectious diseases and what is the future likely to hold? Do we know what really causes disease? What is the basis for host-pathogen specificity and why do some pathogens cross into other species? What would we need to know to predict the emergence and re-emergence of a disease? What do we need to do or know to coordinate efforts on these topics between the EC and US?*

Two primary themes emerged from the workshop. The first was the growing understanding of the complex interactions of disease agents with wildlife and the environment. The second major theme was the need for a greater interaction of different fields of knowledge (e.g., interdisciplinary research, specifically human and veterinary medicine, but also including other disciplines such as ecology, zoology, engineering, meteorology, sociology etc. Finally, the participants highlighted the need for improved infrastructure, improved communication between scientists, and the need for increased international collaboration. One specific area identified as a priority for research and collaboration was the development of new vaccines exploiting the new opportunities provided by biotechnology.

The second workshop on "Advances in Immunology and Vaccine Discovery" was held in Ames, Iowa, USA December 12-14, 2006. The workshop focused on six areas of immunology where new knowledge could allow new approaches to vaccine design: immune evasion, innate immunity, mucosal immunity, immunogenetics, comparative immunology and genomics. This second workshop also gathered scientists working in animal and human fields and included the spectrum of infectious agents (parasites, bacteria, viruses and fungi). In each of the six areas, scientists identified fundamental issues where research efforts are most likely to have a greater impact.



Activities beyond the EC-US task Force itself, also take place. There has been a close collaboration between EU funded projects and USDA- ARS (Dr. Cyril Gay) with regard to notifiable diseases such as classical swine fever, African swine fever and foot-and-mouth disease. Also worth highlighting are the common efforts to promote the Global Foot-and-Mouth Research Alliance (GFRA). An international workshop entitled “Understanding Foot and Mouth Disease Virus (FMDV) Early Pathogenesis and Transmission" held at Pirbright, UK on January 21-22 2010 was jointly organized by USDA-ARS, the Institute for Animal Health (UK) and the European Commission (DG-RTD-E). This focused workshop was extremely fruitful allowing an open dialog between researchers working in the same area. As this dialog continues in the coming years, fruitful collaboration will make the most of limited resources. This focused workshop could be a model for other areas.

Animal Health and Genomics areas were brought together at a 2007 conference on Animal Genomics for Animal Health, held in Paris at the OIE and, though not an EC-US Biotechnology Task Force sponsored activity, this conference was co-organized by Drs. Cyril Gay (USDA-ARS) and Marie-Hélène Pinard (INRA, co-ordinator of 'EADGENE' EC project). The success of this conference is reflected in the second Animal Genomics for Animal Health meeting planned for Autumn 2010 at the OIE.

These activities have contributed to the Task Force's goals of providing a route through which scientists and science administrators could compare notes on the direction and findings of research within the two separate geographic spheres, and beyond. Bringing together top animal scientists throughout the United States and Europe (plus the antipodes and China), has been essential for not only exchanging ideas and information on the leading science of today but in helping to plan the best research for tomorrow. As the investments in research grow, the need for collaboration across boundaries is clear and made even clearer in our workshops. Nevertheless, the lack of funding mechanisms to encourage transatlantic partnership is still a hindrance. Efforts for the better integration of the farm animal research with life science and biomedical communities may provide some opportunities to fund international research efforts.

Looking forward, the US and European counterparts have agreed to update the Farm Animal Genomics Working Group by setting up a formal Working Group on Animal Biotechnology that would encompass, in particular, animal production and animal health and can build on the Animal Genomics for Animal Health conferences being held triennially.

10. OBESITY

In view of the common challenge facing Europe and the United States in preventing and managing obesity and its impacts on public health, well-being and the economy, the EC-US Task Force on Biotechnology Research has encouraged information exchange and collaboration on obesity research. The first exchange of information occurred in 2005. Obesity continues to be a growing threat to health throughout the world. The rise in obesity prevalence has resulted in an increase in the myriad serious medical problems associated with excess body fatness. Obesity is associated with an increased risk for type 2 diabetes, cardiovascular diseases (including hypertension, stroke and heart attacks), certain forms of cancer, and non-alcoholic fatty liver disease, another consequence of obesity that can progress to cirrhosis. Obesity also significantly affects quality of life, including mobility, physical and psychological functioning, and ability to carry out activities of daily living. Weight stigma may contribute to reduced educational and employment opportunities, and decreased access to preventive health care. In addition, the increasing health care costs attributable to obesity-related disorders play a significant role in the increase in health care costs and in lost work productivity.

A wide range of factors are known to influence weight gain and the associated lifestyle behaviors that are associated with increased susceptibility to obesity. These factors span multiple interacting levels, including biological, demographic, psychological, socio-cultural, organizational, environmental, and governmental levels. Given the complex interplay between genes, environment, metabolism, and behavior, simple solutions for altering energy balance toward a healthy body weight appear to be formidable. Identifying and understanding the independent and interacting biological, behavioral, social, and environmental correlates and determinants of obesity and how these differ

between groups is crucial to help identify new targets for intervention at the individual, community, and population levels. Some studies may elucidate how an individual gene or neurotransmitter affects appetite or metabolic efficiency. Other research may explore interactions at multiple levels, such as how genetic variation influences response to behavioral treatment or how policy change affects the risk of obesity development. Thus, with the recognition that obesity research will need to take advantage of converging technologies such as nanotechnology, metabolomics, bioinformatics, epigenetics, bioimaging, and cognitive science, a mechanism to facilitate the interaction of US and EC scientists was timely. It would also enhance the opportunity to assess the interaction of the differential socio-cultural and other environmental influences on the development and management of obesity. Ultimately, research leading to a better understanding of the factors contributing to obesity in individuals and populations, the link between obesity and its associated health risks, and development of improved methods for prevention and treatment has the potential to improve public health in all countries.

Since there is a broad interest relative to addressing the public health problem of obesity, the representatives from the US-EC Task Force on Biotechnology Research have focused on increasing the exchange of research interests and the application of research technologies by collaborative planning of research workshops and sharing announcements of research solicitations. Some of the workshops have been held in association with national or international society meetings in order to inform a broader audience of our interests as well as to have a greater

perspective represented as discussion helped to identify future research directions. A brief description of some of these workshops is provided below.

- A symposium entitled "Neuroimaging and its Potential Application to the Study of Food Intake" was organized for the 6th Annual Meeting of the International Society for Behavioral Nutrition and Physical Activity in June 2007. High-resolution imaging can reveal the connections of how the brain works to translate perceptions, emotions and knowledge. The advances in diagnostics and fundamental knowledge of individual responses to food will be helpful in combating obesity and enable development of functional foods and personalized nutrition for the promotion of health. The discussion demonstrated the increasing interest in this emerging technique by scientists from several disciplines and the opportunities to apply this new technique to better understand consumer attitudes and preferences towards food with a special emphasis to applying the information in our fight against the increasing prevalence of overweight and obesity.
- Some of the research needs and priorities that were brought forward during the above symposium served as a stimulus for another workshop held at NIH in October 2008 entitled "Neuroimaging in Obesity Research"[9]. Although this 2008 workshop was not specifically an US-EC activity, the organizing committee sought recommendations for topics and speakers from the US-EC Task Force on Biotechnology Research obesity representatives. This opportunity offered a constructive mechanism for fostering trans-Atlantic interactions and collaborations.

[9] http://www3.niddk.nih.gov/fund/other/neuroimaging2008/

- Another workshop organised by NIH entitled “Decision Making in Eating Behavior: Integrating Perspectives from the Individual, Family, and Environment” and held in April 2008 offered an additional opportunity for input from the US-EC Task Force on Biotechnology Research obesity representatives to recommend topics and speakers[10]. This workshop offered an opportunity to explore the fundamental decision-making processes and understand the individual, family, and community environmental influences which enhance or constrain healthy eating practices and food choices. Issues that were highlighted during this workshop included: (1) What factors influence a person’s decisions to choose the food that he or she eats? (2) Are our choices for food driven by impulse or is it unconscious deliberation? (3) What are the roles of culture, economics and family dynamics? (4) Do we inherit preferences for certain types of food that override our will to eat a healthful diet? and (5) Will and how can more in depth understanding of determinants of eating behavior improve our interventions geared toward healthy eating? The proceedings from this state of the science of food decision research workshop were published in the Annals of Behavioral Medicine[11] and the contributions made by US-EC staff were appropriately acknowledged.

- In order to identify further research gaps and needs in the area of obesity, the EC-US task force organized a second joint EC-US workshop entitled “Early Life Programming of Obesity” was held outside of Amsterdam in May 2009**.** Early nutrition programming is the concept of following what nutrition at critical periods of early life, both pre- and post-natally, can program a person's development,

[10] http://www3.niddk.nih.gov/fund/other/decision2008/
[11] Volume 38, Supplement 1 / December, 2009
http://www.springerlink.com/content/w75324142n46/?k

metabolism and health for the future. Health problems such as hypertension, tendency to diabetes, obesity, blood lipids, vascular disease, bone health, behavior and learning, and longevity may be "imprinted" during early life. Thus, the potential for improving the health for future generations is enormous.

The purpose of this workshop was to discuss international collaboration in the EC Framework Programme 7 within the area of nutrition and obesity and to bring together experts from different disciplines in order to better understand the effect of early nutrition programming on obesity. The workshop included state-of the-art presentations followed by the identification of research gaps and promising directions for future collaboration beneficial for both sides of the Atlantic.

As a result of this workshop, the following research needs were identified:

- To better understand influence of early nutrition, maternal obesity, diabetes and gestational diabetes on health outcomes of infants
- Programming of fetal and infancy taste and feeding
- Effect of the environment (endocrine disrupters, epigenetic
- Characterize rewarding properties of food
- Characterize the satiating effects of foods and flavors
- Collaborative efforts to follow-up on perinatal clinical trials

In a direct follow-up to this workshop, a focus on the long-term influence of early nutrition on health has been included in Work Programme 2011, to be published in July 2010.

Most recently, meetings were organized in October 2009 to foster dialogue between the research funding agencies focused upon obesity and the nutritional sciences in the US and EC. EC staff visited the US and participated in several interactive sessions at the National Institutes of Health, US Department of Health and Human Services and the Agricultural Research Service, US Department of Agriculture intending to review and refine cooperative mechanisms as well as to consider new and cutting edge common research topics that could be supported on both side of the Atlantic and where clear synergies would be brought to light. As a result of these efforts, program staff from both the US and EC have agreed to informally share plans for the development of respective research initiatives; to seek one another's input as relevant workshops are planned in either Europe or the US; and to further encourage US and EC investigators to have dialogue and develop collaborations. Thus, we are looking forward to continued interactions during the upcoming years.

11. SYNTHETIC BIOLOGY: NEW TOOLS FOR NEW TIMES

Synthetic biology is an emerging interdisciplinary field that offers great promise both for allowing transformative advances in our understanding of the fundamental properties of living systems and for developing innovative new technologies that address critical societal needs, including those related to energy and the environment. One operational, but non-exhaustive, definition of the field is provided by Syntheticbiology.org[12]: (a) the design and construction of new biological parts, devices, and systems, and (b) the re-design of existing, natural biological systems for useful purposes". From the biologist's perspective, synthetic biology is a means to gain insight into basic questions in biology related to areas such as cell processes, gene structure and function, and origin of life that advance our conceptual and theoretical understanding of living systems. Potential applications range from biofuels for energy production, information processing, chemical processing, environmental sensing and remediation, human diagnostics and therapeutics, vaccines, and materials fabrication.

Synthetic Biology is closely rooted in genetic engineering, but it goes beyond the engineering metaphor to adopt conceptual tools, methods and abstractions that come from electric circuitry and mechanical manufacturing. In this sense, synthetic biology aims to make biological systems amenable to engineering from first principles - unlike other man-made artifacts, by bringing in the power of computational modeling sophisticated instrumentation and nanotechnology. In this way, synthetic biology provides an unprecedented opportunity to design biological objects with a la carte properties.

Every new field becomes visible to the wider public through an early

[12] http://syntheticbiology.org/

success story. The production of human insulin by Genetech scientists in 1978 was seen by many as the start of the spectacular development of the recombinant DNA era in Biotechnology. By the same token, the forward design of a complex metabolic pathway for the production of large quantities of the anti-malarial precursor molecule artemisinin has brought about a phenomenal interest in synthetic biology. Dr. Jay Keasling is to be credited for leading a project that has established the feasibility of synthetic biology for this purpose and is in the process transferring the technology for industrial application.

In the US, NSF has invested in both small and large projects primarily in the Engineering and Biological Sciences Directorates. The largest investment (of around $4M/year for a potential 10-year term, now in its 3rd year) is currently with the Synthetic Biology Engineering Research Center (SynBERC.org), headquartered at UC Berkeley, with partners at MIT, Harvard, UC San Francisco, Stanford University and Prairie View A&M University. The Engineering Research Centers (ERC) program funds projects aimed at developing novel and emerging engineered systems. Some of these Centers are developing engineered systems that either are biologically based or are applied to biological systems or both. SynBERC aims to develop foundational understanding and technologies to build biological components and assemble them into integrated systems, to train a cadre of engineers and scientist who will specialize in synthetic biology, and to educate the public about the benefits and potential risks of synthetic biology. The NSF Engineering Directorate has a topic area within the Office of Emerging Frontiers in Research and Innovation on Hydrocarbon from Biomass (HyBi) that is aiming to develop non-ethanol based "green gasoline", which explores Synthetic biology as one of the means to that end. The competition is currently under way.

As one part of an effort to stimulate new and innovative research directions in synthetic biology to address grand challenges, UK EPSRC and NSF co-sponsored an IDEAS Factory “sandpit” on synthetic biology with the Engineering and Physical Sciences Research Council of the UK[13]. Thirty individuals from the UK and the US were chosen from a large pool of applicants who responded to an open call for participants, representing a very diverse range of expertise, including biology, engineering, physics, chemistry, mathematics, computer science, political science, ethics, and economics. These individuals participated in a 5-day interactive workshop (March 30-April 3, 2009) designed to develop novel, creative, and collaborative research projects to address a variety of grand challenges in synthetic biology.

In the EU, the European Commission though its 7th Framework Programme[14] is investing in research activities mainly in the theme of Knowledge Based Bioeconomy. The area of Biotechnologies is supporting a series of emerging technologies, one of them being synthetic biology. The projects on synthetic biology cover topics such as the minimal genomes, aspects of standardization, the notion of cell factory and the application of the technology to environmental problems. In addition and with the collaboration of the "Science and Society Directorate", Biotechnologies is studying issues on ethics, safety and governance.

As with all new and emerging technologies, there are some unknowns with respect to the environmental and health impacts of synthetic biology. It is important to engage a variety of social science disciplines to ensure that scientific research is considered within a societal context and that any ethical, legal and societal issues that are raised are fully explored as the area develops. In the US, NSF has adopted a prospective stance with

[13] http://www.nsf.gov/pubs/2009/nsf09012/nsf09012.jsp

[14] Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013)

respect to ethical, policy and legal issues in supporting SynBERC. This means that experts in the social sciences are engaging synthetic biology researchers on these issues as the technology is developed rather than after the fact. For example, at SynBERC, a research thrust was established at the inception to investigate "Human Practices" aspect of Synthetic Biology looking at both Fundamental ethics research and applied research including security, health and environmental effects. Among the ethical/policy/legal issues that are being addressed by embedded social science researchers in synthetic biology labs are the following: Uncontrolled release, bioterrorism, patenting and the creation of monopolies, trade and global justice, and the creation of artificial life. Many of these issues have earlier counterparts that have been raised in connection with recombinant DNA technology.

In Europe, a report has been issued by the European Group on Ethics of science and new technologies (EGE). On May 28, 2008 President José Manuel Barroso asked the EGE to issue an Opinion on the ethical, legal and social implications raised by Synthetic Biology. The EGE adopted its Opinion on November 18, 2009 and provided some clear indications of next steps for developing the field. In its Opinion the EGE identified and addressed ethical concerns particularly, but not exclusively, from the point of view of safety and security. Beyond this, the ethical reflection addresses justice, governance, science and society dialogue, intellectual property and concepts of life. As for other new technologies, SB must respect the international framework on ethics and human rights and, in particular, the respect for human dignity, which is conceived as not only a fundamental right in itself but 'the real basis of fundamental rights'. Other ethical principles that have also to be taken into account include, *inter alia*, the principles of safety, sustainability, justice, precaution, freedom of research and proportionality.

From an engineering point of view, a grand challenge as expressed by SynBERC researchers is as follows: "Can simple biological systems be built from standard, interchangeable parts and operated in living cells? Or is biology simply too complicated to be engineered in this way?" The challenge is to develop useful tools to reprogram living systems. Biological components can have multiple interactions with complex and redundant cell systems. The apparent absence of an "industry standard" (e.g., the IEEE-standard for electronics) for intermolecular connections in cells complicates the problem of designing an effective and stable system and results in prolonged development times.

Synthetic biology needs to be understood in the larger context of systems biology. Building chromosomes, metabolic or signaling networks or whole cells, ultimately requires the synthetic entity to function as a system that is robust and sustainable. Many challenges remain in order to realize the full potential of synthetic biology, including: (i) developing methods for manipulation and optimization of the flow of metabolic pathways for the production of value added chemicals; (ii) understanding the biological principles of circuit design to create stable and well behaved genetic devices; (iii) uncovering features of the genetic code and the rules for achieving optimal gene expression.

The US-EC Task Force on Biotechnology Research organized a workshop (Airlie House, VA, USA) in 2006 to set out the common interest of US and EU on this technology. The initial discussions included scientific and technical aspects as well as ethical, legal and societal issues embedded in this technology. Since then the two sides of the Task Force exchanged information on their mutual activities

The Task Force will hold a *"Workshop on Standards in Synthetic Biology"* from June 4-6 2010 in Segovia (Spain). The question to be addressed is

how can we best work together across both sides of the Atlantic to increase our capacities for understanding and engineering biological systems at the genome scale? The workshop is being organized as a high-level US-EC discussion on how scientific and engineering research might be best coordinated in order to understand, refine, measure, and, as possible, standardize biomolecules and systems in support of their broad application. From one perspective, new tools such as *de novo* genome construction are challenging synthetic biologists to become much better at reliably programming the functional molecular elements that comprise cells. From another perspective, the complexity of biology continues to challenge systems biologists to develop physical representations of cellular behavior that transcend the simple recapitulation of past observations.

"Twenty years ago the Biological revolution was at its zenith. Unprecedented advances were being made almost on a daily basis in nearly every part of the world. It seemed beneficial to facilitate an open dialog between the EC and the US in the area of biotechnology. Thus, the US-EC Task Force on Biotechnology Research was established… My fervent wish is for the Task Force to continue another twenty years. "

MARY E. CLUTTER

Former Assistant Director for the Biological Sciences Directorate, National Science Foundation, and former US Co-Chair of the US-EC Task Force on Biotechnology Research, from 1990-2005.

"During my 4 years as Co-Chair of the Task-Force I mostly appreciated the trendsetter-aspect in many of the activities of the Task Force: Systems and Synthetic Biology, Nanobiotechnology, Animal Genomics and pandemic diseases, laying the foundations of the knowledge based BioEconomy via biobased products…. Had we not had the Task Force, we would have to create it now!"

CHRISTIAN PATERMANN

Former Director for Biotechnologies, Agriculture and Food Research, European Commission, and former European Co-Chair of the EC-US Task Force on Biotechnology from 2004-2007.