methods of chemical genetics through several mechanisms: (i) The ICCB shares expertise in high-throughput screening by offering information on how to set up a screening facility (*7*) and by providing consultation on technical issues; (ii) the DOS platform and other techniques relevant to chemical genetics developed at ICCB are now available (*8*, *9*); and (iii) the NCI and ICCB by means of the ICG are developing "ChemBank," a suite of informatic tools and federated databases that aim to promote the development and use of chemical genetics (Fig. 1).

ChemBank

One of the missions of ChemBank is to adopt common standards and language that will allow the management and sharing of chemical genetic data. The growing community of academic and industrial scientists interested in data exchange will be encouraged to submit information, using defined standards, on the structures and activities of small molecules. ChemBank is being developed to facilitate the identification of the proteins to which small molecules discovered in cellular and organismal assays bind, and to explore the underlying principles of biological networks. The ICCB will populate ChemBank's databases with baseline information generated by the ICG-funded systematic screening group, with an additional aim to incorporate the large body of data being produced outside of the ICCB. In addition, analysis tools are being developed to relate the selection of reagents, appendages, and pathways in DOS to the swaths of chemical or biological spaces of interest.

Although ChemBank is still in its infancy, selected tools and databases are becoming available; as an example, an interactive database of information on over 2000 known bioactive compounds is now available (*10*). We invite and encourage readers that have access to data on small molecules to participate in this open-access forum by contributing information to the bioactive database of ChemBank. We hope that ChemBank will be a planning and discovery tool for chemists and biologists worldwide, providing unfettered access to the data and tools of chemical genetics.

A Hopeful View of the Future

The chemical description of DNA by Watson and Crick forged an everlasting connection between chemistry and genetics. Now, in this 50th year after their landmark publication, we expect that the ICG will catalyze a new era, in which advances in chemistry are applied toward understanding the functions of DNA and its encoded products. The completion of the human genome sequence will provide definition of the precise chemical structure of the human chromosomes. Through the precise chemical perturbation of biological processes, we hope to advance our knowledge of the functions of the human genome and to intervene in disease processes as we strive toward the betterment of human health.

During the past century there have been many examples of researchers identifying and using small molecules to probe aspects of biology, generally on an ad hoc basis, and it is a long-range goal of the ICG to transform their use into a general and systematic approach to understand biology and medicine (*11*). Furthermore, in light of the new research facilities for small-molecule screening that are increasingly dotting the landscape, the ICG aims to provide tools and information to the scientific community so that the chemical genetic approach can be integrated into the fabric of day-to-day life science research. We hope that, in the future, biologists will have routine access to small-molecule probes to modulate the individual functions of their favorite protein or to dissect networks by the instantaneous modulation of combinations of proteins (*12*). Cheminformatics will no longer be largely the province of the pharmaceutical industry, and chemists will exploit their skills in organic synthesis to populate currently virgin swaths of chemical descriptor space or, even better, the swaths of chemical space that are empirically identified as optimal for overlap with a medically relevant area of biology descriptor space. A key premise of the ICG is that the use of chemistry and information science as up-front discovery tools can diminish the gap between biology and medicine in the future.

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VIEWPOINT

Developing a Platform for Genomic Medicine in Mexico

Gerardo Jimenez-Sanchez

Mexico is preparing to develop a genomic medicine program focused on national health problems. Modern Mexicans result from an admixture of more than 65 native Indian groups with Spaniards, leading to a unique genetic makeup and a characteristic set of disease susceptibilities. Since 1999, more than 100 experts from different fields have joined efforts with government, academia, and industry to identify priorities and goals for genomic medicine in Mexico. The plan includes establishment of an Institute of Genomic Medicine with strong intramural and extramural programs. This project is expected to ease the social and financial burden of health problems in Mexico.

In Mexico, resources are limited and issues such as access to maternal and child care, provision of clean water, and proper nutrition and education continue to be a high priority. Against this backdrop of immediate needs, a large investment in developing genomic medicine might seem unreasonable. However, chronic, infectious, and degenerative diseases are major causes of mortality in Mexico today (*1*). These health problems represent a serious financial burden. Direct costs of diabetes alone account for 4 to 6% of the total annual health budget (*2*). New strategies for prevention, early diagnosis, and more effective treatment are essential to meet the mid- and long-term health care costs in Mexico. Although economic limitations often cause developing countries to postpone the implementation of novel technologies, taking advantage of the current window of opportunity to develop genomic medicine will contribute to economic growth and social welfare. The modern population of Mexico has a characteristic genetic structure, as shown by polymorphisms in blood group systems, serum proteins, major histocompatibility complex genes, and microsatellites (*3, 4*). These observations suggest that genomic medicine in

Consortium for the Institute of Genomic Medicine of Mexico, Camino al Ajusco 130-101, Col. Jardines en la Montaña, Mexico DF 14210, Mexico, and McKusick-Nathans Institute of Genetic Medicine, Johns Hopkins University, Baltimore, MD 21205, USA. E-mail: gjimenez@inmegen.org.mx

Mexico needs to be based on the genetic structure and health demands of the Mexican population, rather than importing applications developed for other populations. For these reasons, genomic medicine has become a priority of the Mexican government in the areas of health care (*5*) and medical research (*6*). After 3 years of preparation, Mexico has set in motion a plan for a national platform for genomic medicine.

Bases for a National Platform for Genomic Medicine

In 1999, a group of biomedical experts mainly from the Ministry of Health (SSA), the National Autonomous University of Mexico (UNAM), the Mexican Health Foundation (FUNSALUD) representing the industrial sector, and the National Council of Science and Technology (CONACYT) analyzed the potential impact that genomic medicine could have in Mexico and identified initial goals for the introduction of genomics into Mexican medicine (*7, 8*). They designed a plan with three 5-year periods to establish, develop, and consolidate a robust platform for genomic medicine in Mexico. An initial budget calculation estimates a cost of $190 million (U.S.) for the first 5 years. This includes construction and implementation of high-technology core facilities and collaborative projects. This investment is reasonable in the context of the national health budget. In 2001, Mexico's total health expense represented 5.7% of its gross domestic product. From that, federal contributions for health care were made in the amount of ~$4600 million (43,450,217,600 Mexican pesos) (*9*). In this context, $190 million in 5 years represents an annual cost equivalent to 0.82% of the 2001 federal contribution to health care.

The current plan consists of three components: (i) a consortium, formed by the four participating institutions, to coordinate the academic, organizational, financial, and legal activities necessary to develop a new Institute of Genomic Medicine (Instituto de Medicina Genómica, or INMEGEN) in the Mexican National Institutes of Health (M-NIH); (ii) a strong intramural program to provide expertise, biomedical research, and technological capabilities; and (iii) an extramural program or "horizontal dimension" fostering domestic and international collaborations, to be coordinated by the institute.

The Consortium for the Institute of Genomic Medicine

On November 2001, the organizing institutions founded the Consortium for the INMEGEN. The consortium has established scientific collaborative agreements with three institutes in the M-NIH and has identified more than 100 candidates for the intramural faculty with expertise in genomics, bioinformatics, and medical research. Most are Mexicans currently at academic institutions in Mexico and abroad. The consortium has also sponsored more than 40 lectures on topics related to genomic medicine, given by leaders in the field. Thirty-two are available on the Web in Spanish (*10*) and have been widely used in the Spanish-speaking world. In addition, the consortium has produced educational brochures in Spanish, English, and French (*11*).

Together with the UNAM, the consortium has established three new graduate courses in genomic medicine: Introduction to Genomic Medicine, Genomic Pediatrics, and Genomic Applications to Internal Medicine. These courses, offered for the first time in Mexico, are part of the graduate Program in Medical Sciences at UNAM (*12*). The Consortium's 2002 Annual Report (*13*), detailing programs and activities, can be obtained on the Web (*10*).

The Mexican Institute of Genomic Medicine (INMEGEN)

The president of Mexico, the secretary of health, and all the political parties have shown great interest and enthusiasm for the creation of INMEGEN, and we are hopeful that it will open in 2003. Its mission will be to apply knowledge derived from the human genome to improve health care through cost-effective interventions for the prevention, diagnosis, and treatment of national health problems; to develop genomic research and training; to implement technological innovation; and to educate the public. Selected examples of research priorities for INMEGEN include the analysis and characterization of genetic variation in the Mexican population (which contains more than 60 ethnic groups); identification of single-nucleotide polymorphisms associated with diseases and drug responses common in the Mexican population; and characterization of the molecular mechanisms of these diseases.

INMEGEN is planned to be in the city of Cuernavaca, state of Morelos, Mexico. The intramural structure will house 10 research laboratories focused on various aspects of genomic medicine. The infrastructure will include teaching facilities, high-technology core facilities, and a clinical research (inpatient) core to serve both the intramural and extramural programs. The institute will also serve as a focal point to develop biotechnology and to facilitate the development of intellectual property related to genomic medicine.

The extramural program or "horizontal dimension" will consist of three elements: collaborative research projects with investigators in other institutions in Mexico and abroad; dissemination of genomic medical applications to other M-NIH and hospitals around the country; and interaction with the industrial sector, with special emphasis on the pharmaceutical industry (*14*) to enhance the production of pharmaceuticals and diagnostic tests derived from the genomic research activity. This horizontal dimension provides an integrative approach to national, regional, and global health problems.

Other Issues

Genomic medicine has received intense attention from different sectors of Mexican society. Indeed, public debate on the ethical, legal, and social issues related to genomic medicine has found many forums, including sessions about genomic medicine broadcasted nationwide through the Mexican Congress television channel. These sessions examined issues such as confidentiality, the right of every person to decide about his or her own genetic testing, community consultation, informed consent, and the risks of discrimination and stigmatization.

In parallel, other developments in Mexico will provide a favorable context for the growth of genomic medicine. For example, the Law for Science and Technology approved by the Mexican Congress in June 2002 coordinates and stimulates the development of science and technology as part of a state policy applied to problems of Mexico. The Mexican Congress is currently considering three initiatives related to the human genome: modification of the General Health Law to prevent genetic discrimination, addition of INMEGEN to the M-NIH, and definition of a position regarding human cloning.

This project faces many challenges, such as the availability of sufficient human resources, sustained financial support, and development of the appropriate legal and social framework. Although previous experiences of institutional development in Mexico indicate that the 10 years following the initial 5-year program described will be a period of development and consolidation of this platform, we have not yet prepared a budget because the field of genomic medicine is still an emerging and dynamic one. We believe that the success of this coordinated effort for genomic medicine has tremendous potential to ease the health and financial burdens of the Mexican population.

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