



New tools, technologies, collaborations, and human resources—from investigators to participants in clinical studies—are helping to accelerate diabetes research. *(Photo credit: Getty Images.)*

RESOURCE AND INFRASTRUCTURE NEEDS FOR DIABETES RESEARCH

contents:

Introduction

Key Questions and Future Directions for Resource and Infrastructure Development

- Research Training and Human Resource Development
- Diabetes Research Resources
- New Technologies, Methodologies, and Measurements for Research
- Animal Models for the Study of Diabetes and Obesity
- Distribution and Sharing of Human Data and Biosamples
- Public-Private and International Partnerships

INTRODUCTION

Diabetes and obesity are complex medical problems with numerous causes that range from genetic susceptibility to behavioral and environmental factors. Diabetes affects organ systems throughout the body, and management of the disease to prevent or treat complications depends on multiple factors, such as an individual's age, the presence of comorbidities, and level of access to health care. Over the past decade, NIH-supported research has led to significant advances in understanding the causes of type 1 and type 2 diabetes, diabetes complications, and obesity (a strong risk factor for type 2 diabetes), as well as to new approaches and technologies for their management. Remarkable progress has been made in detecting regions in the human genome containing genes that modify risk of these diseases. For both forms of diabetes, improved glycemic control has been shown to slow the progression to complications of the disease. For type 2 diabetes,

the demonstration that the disease can be prevented or delayed with lifestyle changes and/or medical intervention has offered new hope that the rising epidemic can be contained or perhaps reversed.

Despite this substantial research progress, diabetes and obesity continue to place a large burden on the U.S. health care system and on affected individuals. Addressing the complexity of diabetes, obesity, and their care requires the collaborative efforts of the research and clinical communities, as well as the establishment of, and broad access to, shared research resources and state-of-the-art technologies. Strong NIH support for resource and infrastructure development is critical to the successful implementation of the strategic research plan for diabetes and obesity research that is laid out in the preceding chapters of this report.

KEY QUESTIONS AND FUTURE DIRECTIONS FOR RESOURCE AND INFRASTRUCTURE DEVELOPMENT

In developing this strategic plan, the working groups identified six categories for resource and infrastructure development that, if pursued, could advance all aspects of basic, translational, and clinical research on diabetes and obesity. These categories address the need for a well-trained, diverse workforce; the benefits of creating common resources and opportunities for collaboration; the need to develop and apply advanced technologies and novel animal models for diabetes and obesity research; the importance of disseminating information about shared resources and developing policies for protecting the privacy of medical and other information about participants in research studies to facilitate access to those resources that include such information; and the synergies that are possible from public-private research partnerships.

Research Training and Human Resource Development

The diabetes research enterprise requires a diversely-trained, multidisciplinary, and interactive workforce to fully address the complexity of disease etiology and its treatment. In addition to attracting, training, and retaining the best and brightest new researchers to the study of diabetes, it is necessary to build multidisciplinary research teams that can pursue strategies based upon an integrated view of diabetes risk, progression, and care. To stay at the leading edge of biomedical research, it is critical to encourage investigators with a wide range of expertise, as well as those in emerging or non-traditional disciplines, to apply their skills to important problems in diabetes research.

Key Questions

- **How can training and career development in all aspects of diabetes research be enhanced?**
- **What programs can be developed to train multidisciplinary researchers capable of examining interactions among biological, psychological, behavioral, social, and environmental factors that have an impact on diabetes and obesity?**
- **How can biomedical engineers, computational biologists, mathematicians, and experts in disciplines not traditionally applied to the problems of diabetes, obesity, and complications be encouraged to pursue research on these diseases?**
- **How can training of physician-scientists be supported in critical areas such as genetics/genomics and biostatistics, population-based methods, and interventional research?**
- **How can investigators from under-represented minority groups be more effectively encouraged to pursue research careers that are focused on diabetes and obesity?**
- **What educational opportunities can be developed for clinical practitioners and for the general public to encourage participation in clinical research?**

Future Directions

- **Incorporate transdisciplinary research opportunities into training programs related to diabetes and obesity.**

Understanding, preventing, and treating diabetes and obesity require innovative approaches that address complexity and blend the perspectives and skills of multiple disciplines. New or expanded programs that give investigators the opportunity to cross-train in more than one field would create innovative approaches and generate novel research strategies.

- **Create training programs that encourage the application of new fields of study to key problems in diabetes.**

As biomedical technologies have become increasingly sophisticated, a need has developed for recruitment of scientists with expertise in computational biology, statistical genetics, engineering, nanotechnology, imaging, medical informatics, bioinformatics, mathematics, social sciences, and other disciplines to diabetes research. Training programs that introduce such scientists to diabetes and obesity research are critical in order for this field to capitalize on the development of advanced research technologies and remain at the leading edge of biological research.

- **Enhance training opportunities for basic and clinical investigators and establish opportunities for translational research in all aspects of diabetes and obesity research.**

NIH currently supports multiple training and career development opportunities for investigators at all stages of the research career trajectory, from graduate or medical school to postdoctoral training and the establishment of an independent research

program. Efforts are needed to communicate these opportunities to trainees with an interest in diabetes or obesity research and to ensure adequate support for a pipeline of new, well-trained investigators in basic and clinical disciplines related to these diseases. Moreover, efforts are needed to enable the retention of new investigators in the diabetes research field as they make their critical, and often difficult, transition to research independence. In addition, new programs are needed to foster translational research training so that experimental results are efficiently converted into real-world solutions to improve the health of individuals living with diabetes or obesity.

- **Develop programs to educate the medical community and the general public on clinical research.**

The success of clinical research and clinical trials depends on researchers' ability to recruit and retain willing participants. Collectively, clinical research and trial protocols for diabetes and obesity require both healthy volunteers and those with diabetes or obesity, with a wide spectrum of personal characteristics (e.g., age, sex, race, ethnicity, and medical history). Education programs are needed to help the public understand the process of clinical research, as well as the risks and benefits of participation in observational and interventional protocols. Similar programs are needed to engage clinical practitioners who could refer their patients for potential enrollment in appropriate studies.

Diabetes Research Resources

A major obstacle to research on human diabetes and obesity is the difficulty in obtaining high-quality human cells and tissues. While major efforts in type 1 and type 2 diabetes have been implemented for establishing DNA resources, individual investigators, particularly

those trained in basic science, might not have the appropriate expertise or access to patient populations in order to acquire or collect biosamples from people with or without disease. Others lack sufficient funding and space to collect, annotate, and store the hundreds or thousands of human biosamples that are needed for some studies, for example to search for biomarkers of disease progression. In the case of some conditions or tissue collections, it may be difficult for a single investigator or institution to obtain enough samples for research. The establishment of central research resources can alleviate these issues by providing broad access to well-annotated biosamples and clinical data more efficiently and at lower cost than would be required for individual investigators to develop multiple, potentially duplicative resources. Other shared resources, such as patient registries and mechanisms to encourage interactions among diabetes and obesity centers, researchers, and clinicians, would also promote the more efficient use of resources and create research synergies.

Key Questions

- **How can access to high-quality human islets and pancreatic tissue for research be improved?**
- **What data registries or biobanks of human tissues and cell lines from people with and without diabetes would best support diabetes research?**
- **How can long-term studies of diabetes and its complications be optimized to provide research data and resources to the diabetes research community?**

- **How can transdisciplinary research and collaboration be encouraged, publicized, and supported across departments, institutions, and methodological fields?**

Future Directions

- **Establish biobanks of annotated human tissue samples related to diabetes and obesity etiology and diabetic complications.**

Improved access to human tissues would accelerate nearly all aspects of diabetes and obesity research. For example, important differences between rodent and human islet physiology are well-documented. Scientists who are studying the role of the beta cell in human diabetes, or developing better methods for islet transplantation, rely on central procurement and processing centers for access to human cadaveric islets, and continued support for this resource is critical. A supply of human islets from individuals across the disease spectrum is necessary for efforts to understand the pathogenesis of diabetes and to provide cellular and molecular profiles that serve as a roadmap for research on embryonic stem cells and induced pluripotent stem cells. Expansion of the islet procurement processes to include islets and pancreata from individuals with type 2 diabetes and other forms of diabetes is needed. The Network for Pancreatic Organ Donors with Diabetes (nPOD) was begun as a pilot project of the NIH-supported Diabetes Centers program and was then expanded by the JDRF to collect, characterize, and distribute pancreatic and other tissues from cadaveric organ donors who had type 1 diabetes or were at high risk for developing type 1 diabetes. Further expansion

of this resource to include procurement of pancreata from individuals with type 2 diabetes and other forms of diabetes is needed. Extended support for resources such as processing centers for islets, fat, muscle, and other tissues would promote research on features of human diabetes and obesity that differ from those present in experimental models of diabetes. Support for these resources and biobanks of tissues, including fat, liver, muscle, eye, nerve, kidney, and blood vessels, is critical for translating basic science discoveries to human physiology and pathophysiology. Such biobanks would complement existing NIH-supported repositories that collect, store, and distribute human biosamples and data from clinical trials. It is critical that any material collected in this fashion be carefully annotated with regard to relevant clinical and medical/family historical information and that DNA be banked as well.



Saving samples from large clinical trials and other studies helps the diabetes research community to capitalize on these resources in new and future efforts. (Photo credit: © iStockphoto.com/choja)

► **Follow cohorts of individuals with type 1 diabetes and youth with type 2 diabetes longitudinally.**

It is critical to be able to study large numbers of individuals with diabetes longitudinally to understand the clinical course of the disease and outcomes of established and new treatments. Efforts should be made

to capitalize on existing cohorts, by extending follow-up of individual cohorts and promoting cross-cohort analyses, and to create new cohorts, where needed. Major new findings have already emerged from long-term follow-up of participants in clinical trials a decade or more after the randomized phase of the study, and similar important observations can be anticipated from follow-up of participants in current clinical studies. By studying large numbers of individuals with type 1 diabetes, researchers could develop new hypotheses for environmental triggers of type 1 diabetes onset and/or progression. As new therapies are developed to treat or prevent type 1 diabetes, longitudinal studies will be essential for tracking long-term efficacy and safety. Long-term safety studies are especially important for immunomodulatory therapies. In addition, studies are needed to better understand the time course and molecular mechanisms for development of complications in individuals with type 1 diabetes, particularly cardiovascular disease, and to understand how CVD risk factors can be effectively modulated. Long-term studies are also essential to understanding the clinical course of type 2 diabetes in children and adolescents, particularly the natural history of beta cell function and the development of complications. A better understanding of the factors that lead to deterioration of beta cell function may promote the development of strategies to maintain beta cell function, making diabetes easier to treat, or even possible to reverse. Finally, several small, clinic-based studies suggest that young people who develop type 2 diabetes may have a more virulent course, with earlier development of complications, but this has not been systematically studied.

- ▶ **Develop mechanisms to foster communication and collaboration among researchers and clinicians with an interest in diabetes and obesity.**

Mechanisms to facilitate interactions among basic scientists studying model organisms and animal models of disease, clinical researchers focused on human disease, multidisciplinary researchers with a broad view of disease, and medical practitioners who treat people with diabetes could have a transformative impact on diabetes and obesity research. Sharing of resources, such as newly developed animal models, and improved communication among these groups could accelerate the translation of important findings from transgenic mouse and other technologies into human studies. Sharing information from clinical practices, perhaps through de-identified medical records, could spur new insights or hypotheses for research. Establishing formal interactions between investigators studying genotypes and phenotypes related to diabetes and obesity could stimulate new lines of research. Promoting cross-disciplinary interactions could be incorporated into the missions of existing NIH-supported Centers for diabetes, obesity, or nutrition research.

- ▶ **Promote interactions between NIH-supported Centers for diabetes and obesity research and other research institutions to maximize access to state-of-the-art resources and training.**

The NIH supports multiple Centers that provide core resources for diabetes and obesity-related research. These Centers help to establish an interactive community of researchers within their home institution, and some Centers, such as the Clinical and Translational Science Awards, also support research training and translation of research into community

settings. With additional resources and incentives, Centers could be encouraged to extend their reach to external diabetes and obesity researchers. By providing services, training, and access to advanced technologies to a broader community, Centers would enable research that might not otherwise be possible, and build a larger, collaborative network of diabetes and obesity researchers.

New Technologies, Methodologies, and Measurements for Research

Over the past decade, the development of advanced technologies and methodologies has revolutionized the biomedical research field and allowed researchers to probe human biology at a level of detail, and with an efficiency, that was previously impossible or extremely time-consuming. Now, high-throughput sequencing techniques permit unbiased, genome-wide searches for disease susceptibility genes. Advanced bioinformatics approaches make it possible to mine extremely large datasets, which can both answer specific research questions as well as generate new hypotheses through complex systems and integrative computational approaches. New methodologies and measurements for studying human behavior facilitate research to understand how the environment affects health and disease. These and other state-of-the-art technologies and methodologies have the potential to open up significant new avenues in the study of diabetes and obesity.

Key Questions

- **What DNA/RNA/protein sequencing and other technologies are needed to identify and study diabetes candidate genes and to better correlate genotypes with phenotypes in humans?**

- **How can mouse or cellular models be developed that are informative about the functional consequences of genetic differences associated with diabetes or obesity?**
- **How should evolving proteomic and metabolomic approaches be harnessed for diabetes research?**
- **What imaging technologies and resources are needed to advance research on diabetes, obesity, and related complications in humans?**
- **What bioinformatics resources and statistical approaches need to be developed or made more accessible to facilitate diabetes research?**
- **What tools are needed to measure energy balance in free-living humans (versus controlled research environments)?**
- **What new analytic methods or tools are needed to study complex, multi-level interactions within populations that affect obesity?**
- **Can standardized methods be developed for assessing predisposing behaviors and outcomes in human obesity trials?**
- **How well do self-reported and observational measurements correlate with biological markers?**
- **What are the best research designs to study causality in sociological systems?**
- **Can new instruments be developed to measure health promotion outcomes across communities and populations?**
- **How can more efficient communication be encouraged between people with diabetes and health care providers?**

Future Directions

- **Develop and make available advanced technologies for discovering diabetes genes in humans.**
- **Develop analytical methods for epigenetic processes and other resources to study the relationships among genotypes and phenotypes in humans.**
- **Establish banks of monoclonal antibodies specific for diabetes-associated proteins.**

Methodologies such as a \$1000/genome sequencer, high-throughput RNA sequencing, and deep sequencing technologies are being developed that can help to define the universe of diabetes-associated genes and to correlate genotypes with phenotypes. In addition, these and new high-throughput screening technologies will aid in the development of pharmacogenetic approaches to determine which individuals are most likely to benefit from particular therapies. New rodent, human, and mathematical models, as well as monoclonal antibodies to disease-associated gene products, are needed to definitively establish the importance of diabetes candidate genes and to facilitate their in-depth study. New methodologies for detecting and interpreting epigenetic processes would help researchers better understand how the environment influences the link between genotype and phenotype in individuals with diabetes or obesity. Evaluating the impact of epigenetic modification will require research to determine the extent to which readily accessible cells, such as those

from blood or skin, accurately reflect epigenetic patterns in diabetes-relevant tissues, like pancreas or liver, that are less accessible for routine analysis.



New technologies facilitate advances in diabetes research. (Photo credit: © iStockphoto.com/dra_Schwartz)

Central core laboratories with access to sophisticated equipment and personnel who are well-trained in the application of state-of-the-art methodologies for sequencing, epigenetic analysis, and antibody generation and validation would be an invaluable resource. By generating high-quality reagents and data using uniform protocols, such cores could extend the application of these technologies to the broad diabetes and obesity research community and enable the direct comparison of results among laboratories.

- **Create novel cell lines and related resources for diabetes and obesity research.**
- **Encourage new approaches to diabetes research and treatment based on stem cell technology.**

Discovering ways to efficiently differentiate stem cells into insulin-producing beta cells could supply an unlimited source of beta cells to study the molecular pathogenesis of type 1 and type 2 diabetes and, ultimately, for therapeutic replacement. The development of mutation-specific hypothalamic neuronal cells lines, perhaps through the use of induced

pluripotent stem cell (iPS) technology, would provide an important tool for obesity research. Likewise, cell lines from people with diabetes could reveal novel molecular signatures reflective of disease subtypes. New cell lines for the study of vascular biology and vascularized patches would aid research on diabetic complications. Encouraging the development of these and other cell lines, whether based on stem cell technology or more conventional approaches, would promote new opportunities for diabetes and obesity research and treatment.

- **Make new technologies available as they arise, including stem cell resources.**

The development of iPS cells from individuals with diabetes could benefit many lines of research, including investigation of how specific genetic variants influence disease and the development of personalized therapies. Creating a biobank of disease-specific, well-annotated iPS lines or other experimental cell lines or reagents would make these tools available to a broader community and encourage innovative research.

- **Apply proteomic and metabolomic methodologies to research on diabetes and obesity.**

Proteomic technology enables researchers to study the entire set of proteins, including their relative abundance and the presence of post-translational modifications, in a particular cell or tissue. This technology can also be used to evaluate how those proteins and modifications differ among tissues or under varying conditions. For example, the protein complement in healthy kidney tissue can be compared to that in kidney tissue from a person with diabetic nephropathy to determine which molecular pathways are affected by the disease. Similarly, metabolomics can be used to assess the

presence of metabolites and the flux through metabolic pathways in various states of health and disease. Applying proteomic and metabolomic technologies has the potential to uncover alterations in biochemical pathways associated with obesity and diabetes, suggest new targets for therapeutic intervention, and identify biomarkers of their development or progression.

► **Develop advanced, noninvasive imaging techniques that can be used in living humans.**

A critical gap in diabetes and obesity research is the lack of reliable, affordable, noninvasive methods to image relevant cells and tissues in living humans. Innovative approaches are needed to assess pancreatic beta cell mass and function, study adipose tissue and measure adipocyte turnover, improve functional brain imaging, and monitor the development and progression of end-organ complications, among other uses. The development of enhanced imaging techniques would benefit basic research on disease pathology and accelerate clinical trials by more quickly and specifically evaluating trial participants' responses to new therapies.

► **Develop statistical and bioinformatical methods and resources for integrating and analyzing large datasets generated by state-of-the-art technologies.**

Many advanced technologies, including deep sequencing, proteomics, metabolomics, and imaging, generate massive datasets. New bioinformatics approaches are needed to analyze and mine these data sets to derive conclusions and generate new hypotheses. In addition, bioinformatics approaches are required to relate and integrate data generated by different technologies—for example, to correlate genotypic data from a deep sequencing project with phenotypic data derived from an imaging technique or a proteomic assay. Such

approaches can help researchers develop a systems-level understanding of diabetes and obesity, which have wide-ranging effects on the body.

► **Design innovative tools for studying energy balance under real-world conditions.**

Advances in diabetes and obesity research have shown promise for preventing or treating these diseases in participants enrolled in carefully controlled clinical trials. Translating these results to real-world conditions requires new tools for both short- and long-term monitoring of energy intake, energy expenditure, physical activity, and relevant behavioral assessments in humans. Such tools must be accurate and cost effective for use in real-world conditions over time.

► **Develop new methods for studying the impact of the environment on obesity.**

Research clearly demonstrates that a person's environment makes a significant contribution to their risk for obesity. New analytical methodologies are needed to study complex, multi-level interactions within populations, including the effects of social networking and the built environment, in relation to obesity.

► **Improve and standardize measurements for translational research.**

Standardizing the use of effective behavioral and environmental measures would facilitate comparison of results from translational research projects in diabetes and obesity. In particular, standardized clinical outcomes measures, both self-reported and observational, and standardization in community and population methods, including sensitivity to differences among populations, are needed.

► **Develop new methodologies for comparative effectiveness research.**

The variety of pharmaceutical, biologic, and/or behavioral therapies for diabetes and obesity can create uncertainty among clinicians and patients regarding the most effective and appropriate treatment. Comparative effectiveness research aims to directly compare two or more therapies to determine the best treatment for individuals. Such research might involve head-to-head clinical trials, evaluation of past trials, or analysis of outcomes data from clinical registries, data networks, or other electronic records.

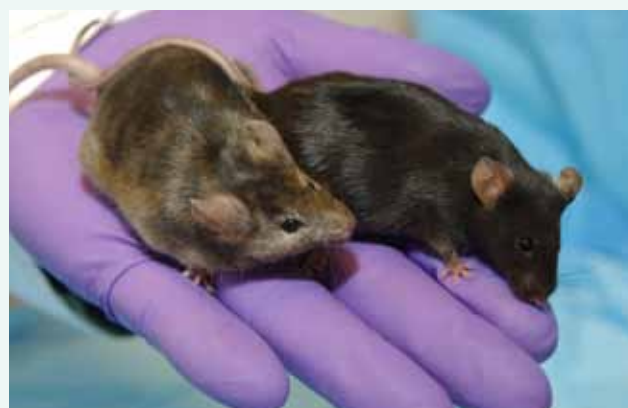
► **Develop advanced Web-based and mobile technologies for capturing clinical data, enhancing education, and facilitating data management.**

Diabetes and obesity researchers have an opportunity to capitalize on emerging Web-based and mobile technologies to enhance clinical research as well as translational research to implement research findings in the community. These technologies offer the potential for real-time collection of clinical data, more frequent communication between researchers and trial participants, and improved data management.

Animal Models for the Study of Diabetes and Obesity

Biomedical research relies on the use of animal models for studies of physiology and pathophysiology that are not possible in humans. Animal models are also essential for pre-clinical testing of new therapeutic agents to assess safety and efficacy before human trials can begin. Although research on animal models has led to great insights on the causes, progression, and treatment of diabetes and obesity, no animal model perfectly mimics these diseases in humans. For example, diabetic

mouse models do not all develop the same range of end-organ complications as humans. Similarly, non-human primates, which are an important model of islet transplantation for type 1 diabetes, do not spontaneously develop autoimmune diabetes. New animal models that are more comparable to human diabetes and obesity would help researchers to better understand these diseases, develop new interventions, and predict how people will respond to potential new therapies.



Animal models are important to research efforts to understand and develop interventions for diabetes and obesity. (Image credit: National Human Genome Research Institute, NIH.)

Key Questions

- **What new small and large animal models are needed to accelerate research on type 1 and type 2 diabetes?**
- **Can animal models be developed that mimic human obesity etiology and treatment outcomes?**
- **Can animal models be developed that better simulate complications of human diabetes? Can new biomarkers be defined for complications in both animal models and humans?**

- **How can functional brain imaging techniques be improved for use in animal models?**
- **What new resources are needed to improve the phenotyping of animal models for diabetes and obesity?**

Future Directions

- **Develop new small and large animal models that better represent the pathology and treatment of human diabetes and obesity.**
- **Develop *in silico* models of disease pathogenesis in type 1 and type 2 diabetes.**

Research is needed to develop novel small and large animal models that more closely simulate human type 1 diabetes, type 2 diabetes, diabetes complications, and obesity. The development of mouse models with immune systems more closely resembling those of humans, as well as primate models of autoimmunity, is critical to understanding the immune process in human type 1 diabetes. Better models of beta cell autoimmunity could lead to new insights regarding beta cell function, failure, and regeneration that might be applicable to both major forms of diabetes. Animal models that more closely mimic human type 2 diabetes are needed. Mouse models that are genetically modified to label specific neuronal populations could be used to investigate neuroanatomy and function, as well as to understand the causes of diabetic nerve damage. Animal models of gastrointestinal bypass surgery that mimic the changes in weight and metabolism observed in humans could help scientists understand the hormonal and other short- and long-term effects of this surgery. Animal models of metabolically benign obesity are also needed. These are

only a few examples of the many types of new animal models that could be useful for diabetes and obesity research.

Researchers are now taking advantage of discoveries in computational sciences to build *in silico* models of diabetes. Such models that map complex biochemical pathways and cellular processes can be used to understand the effects of pathophysiologic perturbations, identify therapeutic targets, and predict an organism's response to drugs. *In silico* models might also reveal similarities and differences between the physiology of animals and humans that can lead to new hypotheses of disease development and progression that can then be tested *in vitro* and *in vivo*. Support for the development of improved animal and *in silico* models of diabetes and obesity will help researchers to develop an integrated view of these diseases that can then be translated for the benefit of people.

- **Standardize research protocols involving diabetes-related mouse models.**
- **Develop standard definitions of abnormalities in mouse models of diabetes and obesity.**

Experimental results in animal research are influenced by a multitude of factors, some of which may be controlled. Standardizing controllable aspects of research protocols (e.g., diets, daily care, environmental circumstances, and research protocols) that involve diabetes and obesity-related mouse models would facilitate effective collaboration and comparison of results among laboratories, particularly those located in different medical centers. Likewise, the development of standard definitions of pathophysiology would promote

better comparison and evaluation of experimental results from different laboratories.

► **Develop improved methods and technologies for phenotyping of mouse models.**

Mouse models have proven invaluable for research on many diseases due in part to the ease of genetic engineering in this species and a relatively short generation time. Because of the widespread use of numerous mouse models for diabetes, complications, and obesity research, adequate facilities are needed to make sophisticated phenotyping techniques available to the broad research community. In particular, resources are needed to develop and provide access to advanced imaging technologies for mouse models that can be related to equivalent studies in humans.

Distribution and Sharing of Human Data and Biosamples

As described in the previous sections of this chapter, new diabetes research resources, emerging technologies and methodologies, and animal models would have the most impact if standardized and shared widely within the diabetes and obesity research communities. Likewise, distribution of clinical biosamples and datasets would allow independent investigators to analyze well-annotated specimens and data from multiple perspectives and gain unique insights without the need for duplicative sampling programs. Mechanisms are needed to disseminate information about the availability of biosample and data collections and to ensure the protection of study participants' privacy when materials are made available beyond the originating investigator or group.

Key Questions

- **How can communication be fostered between basic scientists and clinical investigators conducting clinical studies and trials?**
- **How can awareness of and access to human biosamples and data from clinical trials be enhanced in order to facilitate biomarker discovery?**
- **How can awareness and use of new diabetes and obesity intervention programs and research tools be enhanced?**
- **What mechanisms or resources are needed to make datasets of de-identified medical records available to researchers?**
- **How can universal electronic medical records be made accessible for research while safeguarding patient and provider privacy?**

Future Directions

- **Communicate the availability of datasets and biosample repositories and improve access to these resources by qualified diabetes researchers.**

Repositories store human biosamples or maintain datasets under high-quality conditions for long periods of time. Streamlined methods are needed to make the research community aware of new and existing repositories and to make the materials available to qualified investigators in an equitable and ethical

manner. Efforts should be made to standardize data storage formats to facilitate comparisons across studies.

➤ **Improve technology capabilities for dissemination of intervention programs.**

Many intervention programs are being tested for the prevention and treatment of diabetes and obesity. Harnessing new information technologies, including Internet- or PDA-based systems, for the rapid and efficient dissemination of validated intervention protocols, actionable research tools, or related materials would help researchers build on successful programs to stem the epidemic of these diseases in diverse populations across the United States.

➤ **Develop policies that facilitate research using electronic medical records while protecting individuals' right to privacy.**

The development of electronic medical records (EMR) has provided an unparalleled resource for research on both rare and common human diseases. EMRs that are linked to repositories of DNA, pathological specimens, imaging data, or other medical samples are particularly valuable. As EMRs become standardized in the context of health care reform, policies are needed that facilitate research based on these important data sources while maintaining respect for individuals' right to privacy.

Public-Private and International Partnerships

The NIH is the primary Federal agency responsible for conducting and supporting biomedical research in the United States; however, many agencies at the Federal, state, and local levels share a common goal in the protection and improvement of public health. In addition, the United States has a strong biotechnology

and pharmaceutical industry that invests heavily in research and development for new therapies to prevent and cure disease. Private foundations and health advocacy organizations also play a significant role in planning and supporting biomedical research. Foreign governments, multilateral institutions, and international donors also support substantial research efforts and resources that complement efforts in the United States. International research is particularly relevant to the United States, which includes immigrants from around the globe. Much may be gained by understanding the genes and predilection for diseases that these groups brought from their ancestral populations abroad. Already, pooled analyses of hundreds of thousands of samples from many countries have been crucial for identification of diabetes risk genes. Moreover, other countries have health care and medical records systems that are particularly useful for clinical research. By fostering partnerships with other interested agencies and organizations, the NIH has an opportunity to enhance basic, clinical, and behavioral research, accelerate the validation and approval of new therapies, and ensure that the results of its research efforts are disseminated to individuals who have or are at high risk of diabetes and obesity.

Key Questions

- **How can NIH collaborate with clinical care providers and payers to conduct clinical research in real-world settings and to conduct comparative effectiveness research more efficiently?**
- **How can policies for protecting the privacy of research participants be updated to foster multi-center clinical trials, associated biomarker studies, and the**

sharing of genetic materials between the public and private research sectors and internationally?

- **What new NIH policies are needed to facilitate international collaborations?**
- **How can regulatory and financial issues be resolved in order to support the development of glucose management technologies, new therapeutics for microvascular complications, agents for glycemic control with adequate information on cardiovascular and other risks, and combination therapies for diabetes and obesity?**
- **How can NIH support and encourage partnerships between researchers and their local communities?**

Future Directions

- **Build or strengthen partnerships between NIH and other government agencies, the pharmaceutical industry, the health insurance industry, and private foundations with an interest in diabetes and obesity research.**

In addition to the NIH, agencies within the Federal government that are tasked with improving the health of the American people include the FDA, CDC, IHS, VHA, DOD, AHRQ, and HHS—all of which are members of the statutory DMICC. New and existing partnerships, collaborations, and information exchanges among these and other DMICC member agencies should continue to be encouraged, as they are critical to the success of diabetes and obesity research. For example, ongoing dialogue between the NIH and FDA is needed to validate and gain regulatory acceptance of

biomarkers that can dramatically shorten clinical trials of new therapies for diabetes complications. Continued communication is also needed to establish standards for assessing the safety of new cell-based, biological, and genetic therapies for diabetes and obesity. Partnerships between the NIH and public and private insurers could potentially reduce the cost of clinical trials if those organizations pay for usual care that is not part of the trial.

NIH partnership with non-governmental agencies or international research organizations would enhance academic research on diabetes and obesity. In addition, mutual support of research and training partnerships between U.S. and foreign academic institutions will build a cadre of diabetes researchers worldwide who may then collaborate as full and effective partners. Pharmaceutical companies are often reluctant to share genetic material, other biosamples, or data collected in the course of clinical trials due to privacy issues and other concerns. By facilitating interactions between those companies and academic investigators, the NIH could complement and expand on publicly-supported repositories as described previously in this chapter. Likewise, the NIH could act as an intermediary to promote sharing of large datasets and materials between U.S. investigators and those in other countries. Communication and collaboration with non-profit voluntary groups, including the ADA and the JDRF, benefit all parties in the research enterprise by reducing the duplication of resources and encouraging progress toward mutual goals.

- **Foster practice-based and community-based participatory research to promote the prevention and control of diabetes in vulnerable populations.**

Community-based participatory research relies on close collaborations between academic investigators and partners in a local community at all stages of the research process from design and implementation of a study to interpretation of results. It is important to actively involve a wide variety of organized community groups, such as faith-based organizations, schools and workplaces, not only to facilitate the highest quality research on the prevention and control of diabetes, but to ultimately improve the health and well-being of community members. By actively engaging the public,

community-based research has the potential to identify interventions for diabetes prevention and control that are effective and sustainable in distinct populations. Such research can give rise to innovative solutions for reducing health disparities in diabetes prevention and treatment that disproportionately affect individual communities. New approaches are needed to encourage community-based participatory research partnerships in ways that recognize and support the strengths and skills of all partners.

