



**Report of the**  
**Blue Ribbon Panel Review**  
**of the**  
**National Human Genome**  
**Research Institute**  
**Intramural Research Program**

**2011-2012**

## **Preamble**

Roughly every ten years, the Intramural Research Program (IRP) of each NIH Institute/Center is reviewed by a panel of outside experts ('Blue Ribbon Panel'). To review the National Human Genome Research Institute (NHGRI) IRP, Dr. Eric Green (Director, NHGRI) worked in partnership with Dr. Michael Gottesman (NIH Deputy Director for Intramural Research) and in consultation with Dr. Timothy Ley (Chair, NHGRI Board of Scientific Counselors) to constitute a Blue Ribbon Panel in September, 2011. Dr. David Page (Director, Whitehead Institute) was appointed Chair of the Blue Ribbon Panel, which also consisted of six other scientists with a broad perspective on genetics and genomics and considerable knowledge about NHGRI (see attached roster of the Blue Ribbon Panel – Appendix 1).

The review process consisted of four elements:

- A conference call on September 27, 2012 to charge the Blue Ribbon Panel and to finalize plans for the review.
- A two-day in-person meeting of the Blue Ribbon Panel on January 19-20, 2012 (see attached agenda – Appendix 2). During these two days, Panel members were provided with a comprehensive overview of the NHGRI IRP.
- A conference call on April 27, 2012 to regroup to discuss the follow-up related to the initial in-person meeting.
- A two-day in-person meeting on July 26-27, 2012 to finalize input and compile the final report (see attached agenda – Appendix 3).

The Blue Ribbon Panel concluded that the above set of meetings and discussions provided the necessary information and other input for the overall assessment detailed below.

## **Opening Summary of the Blue Ribbon Panel Review**

The NHGRI IRP was founded in 1993. It is currently associated with a research and clinical faculty of ~45, a total staff of ~550, and an annual budget of just over \$100M. The Program is now led by Dr. Daniel Kastner (Scientific Director); previous Scientific Directors were Dr. Jeffrey Trent (1993-2002) and Dr. Eric Green (2002-2009). This is the second Blue Ribbon Panel review of the NHGRI IRP; the initial one being held in 2001 at a time when the program was still in a significant growth phase. It is notable that the current Blue Ribbon Panel review is being held at a distinctly different 'life phase' of the NHGRI IRP, especially in light of the current budgetary circumstances.

The Blue Ribbon Panel concludes that the NHGRI IRP remains an outstanding research enterprise. In broad terms, this is reflected by (1) scientific productivity measured in terms of overall publications; (2) an excellent track record in the training of researchers and clinicians across a diverse set of training programs; (3) enhancement of the broader NIH IRP through the dissemination of genomic technologies and expertise, and the fostering of new programs; (4) the development of an impressive research and clinical

faculty, with international reputations; (5) the establishment of a robust research infrastructure (in terms of cores and centers), and (6) a spirit of collaboration and collegiality among IRP faculty and staff. These various unique attributes are described in greater detail below.

### **Unique Attributes of the NHGRI IRP**

NHGRI has long enjoyed a culture that is unusual among NIH institutes/centers, and has historically been unafraid to "be different" in both its Extramural and Intramural Research Programs. In the case of the IRP, this history affords NHGRI opportunities to experiment with its leadership models and organizational structure in ways that empower its research faculty and invigorate leadership at all levels. The panel particularly appreciates the willingness of Dr. Kastner to tackle emerging challenges in a timely and effective way. Similarly, the willingness of the Branch Chiefs and the NHGRI faculty to question themselves and their leadership on such broad questions as the right emphasis on high-risk research, the right mix of basic, clinical, and translational research, and the right way to balance perceived needs to build expertise in particular scientific areas with the overarching desire to recruit those doing the best and most exciting genomic science is exemplary. For such questions, the inability to achieve consensus should not be viewed as a failure; rather, the dialog itself is the important achievement. The fact that everyone is considering, discussing, and reconsidering their views on these topics is healthy – indeed, it is the primary way that the group can ensure that they will not go far wrong even while they can never be sure that what they ultimately choose to do on any of these topics is exactly right.

The leaders and faculty of the NHGRI IRP are justifiably proud of several areas of significant accomplishment. This IRP is viewed as a leader on the NIH campus in the implementation of new genomic approaches in the study of human biology and disease. Several innovative programs, such as the NIH Chemical Genomics Center and the Undiagnosed Diseases Program, were launched within the NHGRI IRP and have subsequently been adopted as NIH-wide programs. The IRP has also been at the forefront on the NIH campus in the development and deployment of new DNA sequencing technologies along with the bioinformatic approaches required to analyze genomic data.

A second area of distinction for the IRP is that it brought together investigators in basic science, translational genomics, and social and behavioral sciences. The faculty have made extraordinarily good use of the ability to perform long-term studies of rare phenotypes, and then to harness the power of genomics to define the genetic basis of these disorders. It has also made excellent use of the extraordinary resource of the NIH Clinical Center. This is most visible in the accomplishments of the Undiagnosed Diseases Program, but in fact permeates through most of the branches and faculty laboratories. Although the identification of genes responsible for rare disorders is happening throughout the extramural scientific community, the success of the NHGRI IRP in this area is undeniable, and is amplified by the contributions of the NHGRI IRP to work done on rare diseases within other NIH institutes/centers' IRPs. That said, the

NHGRI IRP has not lost sight of the importance of maintaining a robust basic science research program. Genomic approaches are a direct result of basic science research, and the identification of genes associated with phenotypes in genetic disorders spawns new areas of basic science investigation. It may be difficult to directly measure outcomes of basic science research in terms of improvements in human health, and it is difficult to articulate a vision for the future of basic science since one cannot predict what is undiscovered. Nevertheless, the NHGRI mission at NIH would be critically, if not fatally, impoverished without a strong basic science component. The same could be said for the efforts at NHGRI to pursue studies on the clinical implementation of genomics and the assessment of individual and societal outcomes. The IRP has done an exemplary job of demonstrating the power of the genomic approach across the continuum of discovery, translation, and implementation.

A third major contribution of the NHGRI IRP has been in the area of training. The program has embraced a training mission at all levels, including laboratory investigators, graduate students, postdoctoral fellows, physician scientists, medical geneticists, and genetic counselors. Aside from filling a great need for expansion of the genetics and genomics workforce, this commitment is indicative of a deep recognition of the importance of outreach to colleagues in other disciplines, which is critical for the success of the genomic approach. This collegiality is engrained in the NHGRI culture and greatly enhances the impact of the NHGRI IRP throughout NIH and the extramural community.

### **Overall Vision**

Dr. Kastner, together with the faculty of NHGRI IRP, developed a vision statement at the request of the Blue Ribbon Panel that describes the goals of the IRP over the next 5-10 years. The vision statement (Appendix 4) highlights the goal of the program in leading the way on the broader 'NIH campus' in performing innovative genetic and genomic research to gain insights into human biology and human disease. The faculty recognizes the importance of synergies among basic and clinical investigations, and is committed to research excellence in all of their pursuits. The faculty will strive to develop and implement genomic technologies that they will share across the NIH, and they will continue genomic and genetic studies with the ultimate goal of developing molecular taxonomies of human diseases. Beyond disease-oriented research, the faculty will capitalize on discoveries in genetics and genomics to advance basic science. Lastly, the faculty is committed to train the next generation of researchers in genetics and genomics.

Overall, the vision outlined by Dr. Kastner and his colleagues is compelling and incorporates several key components necessary for the continued success of the NHGRI IRP. That said, the vision could be expanded to capitalize more on the unique attributes and resources of the program. Given the strengths in clinical, basic, and computational research, Dr. Kastner and the faculty should set lofty goals that go beyond the current activities of the program. One such goal would be to develop computational tools and research programs that will help decipher the large sets of

genomic data and reveal functional consequences from those data. The NHGRI IRP is positioned to develop new basic science initiatives geared towards understanding the consequences of genomic variations on RNA and protein functions. The ability to combine computational research, in vivo studies of model organisms, and cross-species studies from invertebrates to humans will break open many new fields rather than promote incremental advances. With increasing understanding of the structure of the genome and the consequences of its variations, NHGRI IRP investigators are poised to tackle the challenge of using genomic information in the clinic routinely.

Transforming the practice of genomic medicine is one example of a long-term goal for the NHGRI IRP. Given all the required steps to accomplish such a goal, it would be important for Dr. Kastner and his leadership team to define specific expectations and to charge the faculty with figuring out the best course to realize them.

The NHGRI IRP enjoys the privilege of having ~20% of the Institute's funding. This is different from all other IRPs at NIH, and has the dual effect of evoking higher expectations and exposing the program to more scrutiny. Solving problems that are currently vexing the broader field within the NIH campus and beyond will truly set this program apart.

### **Addressing Operational Issues in the NHGRI IRP**

The leadership of the NHGRI IRP has been tackling a number of important operational issues involving budgeting, the review process, and the organization of the program. Modification of the budgeting process may be necessary in an era of stressed resources and uncertainty about future funding. As unwelcome as these pressures may be, they also force an examination of the priorities of the program and the relative strengths of its components. Although across-the-board cuts may seem the fairest way to manage reduced funding to the Institute, in the long run, this approach can enfeeble all programs. Strategic decisions that allow outstanding programs to grow at the expense of weaker programs are especially important in a time of constrained resources. The decision to provide faculty with discretion in the management of their budgets empowers them to grow the strongest parts of their research programs. Similarly, transparent accounting of core costs, activities, and usage should enable the NHGRI IRP to be nimble and to remain at the cutting edge of a science that evolves at an extraordinary pace.

Faculty who work in the NHGRI IRP enjoy great freedom to take on long-term or high-risk research with stable funding and access to extraordinary clinical and technological resources. The credibility of the program is dependent on a fair and robust process of scientific review. Efforts have been made to standardize the format of material provided to reviewers, to improve the quadrennial review process, and to clarify the consequences of an unfavorable review. The latter is particularly important since, without appropriate follow-up on negative reviews, the entire review process is undermined and the quality of the scientific enterprise of the IRP may be questioned.

The changes that have been implemented seem likely to address these concerns, and should be closely monitored by the NHGRI Board of Scientific Counselors.

The organization of the branches and cores of the NHGRI IRP is based on history and the need to group faculty into a manageable number of administrative units. There are many ways to group the faculty – along thematic lines, by virtue of common use of research tools, or even compatibility in approach to research. The commitment to excellence must be consistent across the Institute, irrespective of the branch identity or theme. Although the branches are expected to be relatively stable entities, it is appropriate to rethink the organization periodically, capitalizing on new research opportunities or tapping into leadership skills of individual faculty. The NHGRI leadership should be encouraged to think creatively about the organization of the branches, and to make strategic decisions to modify the structure if that will enhance productivity of the program as a whole. In addition, we would encourage the leadership team to draft a description of the duties and responsibilities of Branch Chiefs that respects the long-standing differences among the branches with respect to thematic cohesiveness, but is sufficiently descriptive to be helpful in searches, reviews, and evaluations.

### **Possible Risks for the NHGRI IRP**

One source of medium-to-long-term risk for the NHGRI IRP is the striking dichotomy between the investigator-driven ('bottom-up') research agenda of the IRP and the centrally driven ('top-down') research agenda of the Institute's Extramural Research Program. The Blue Ribbon Panel emphatically and unequivocally supports and affirms NHGRI's focus on the individual creativity, productivity, and excellence of its IRP investigators and the latitude given these investigators to establish their own scientific priorities. The Blue Ribbon Panel is concerned, however, that these defining attributes of the IRP will come under increasing scrutiny and criticism from an extramural scientific community that sees a slowly but steadily diminishing fraction of NIH's extramural budget devoted to investigator-initiated pursuits. These trends are not unique to NHGRI, and thus the risks are not unique to the NHGRI IRP. The vulnerabilities are perhaps greatest for the NHGRI IRP for three reasons: First, the dichotomy between the Intramural and Extramural Research Programs is more pronounced at NHGRI than at other Institutes/Centers; second, the NHGRI IRP commands a larger fraction of the Institute's funds (~20%) than at other Institutes/Centers; third, there is, at present, no articulated rationale or justification to account for the dichotomy that exists at NHGRI and that is increasing across NIH. The Blue Ribbon Panel concludes that, in the years ahead, this will be a significant risk to the NHGRI IRP and its funding. We urge NHGRI leadership, and indeed NIH leadership, to confront and address this growing dichotomy before it undermines the viability of the broader NIH IRP as presently constituted.

### **Guiding Principles – Moving Forward**

In a rapidly changing field like genomics, guiding principles are key for navigating the challenges that the NHGRI IRP will face in the coming decade. Our discussions and

interviews touched on several such principles that have been central to the NHGRI IRP's past successes and will serve it well in the future:

1. Embrace a risk-taking culture. Investigators should pursue the next technologies that will increase the pace of discovery in genomics. These advances will be essential to coming to grips with the complexities revealed in the genome sequence that underlie development and disease. This commitment is particularly important in the current tight budget era, during which the natural tendency is to become more conservative.
2. Insist on excellence. This is critical given the large fraction of the NHGRI budget dedicated to the IRP, and requires constant evaluation and the willingness to make uncomfortable decisions. The result can be adjustments that will support the best science and provide an opportunity for change in an era of budgetary constraint.
3. Continue to be a 'change agent' on the NIH campus and beyond. This has been a strong point and, especially now that established technologies are more widely used, the NHGRI IRP can provide leadership in maintaining high standards and in spurring others to gain the full benefits of the advances. Other institutes/centers recognize NHGRI's leadership and are anxious for more help.

One area of expanding need that has already been recognized is in the interpretation of the volumes of genome information that is being captured and its integration with other clinical data. This area will also promote more integration of the NHGRI with the other NIH institutes/centers. But the NHGRI must build on this success and begin thinking about the next opportunities, so that its role continues into the indefinite future. Reinforcement now of these key principles will position the NHGRI IRP for an even greater impact when resources again become more plentiful.

## Appendix 1

### Blue Ribbon Panel Review of NHGRI Intramural Research Program (2011-2012)

#### Blue Ribbon Panel Roster

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## Appendix 2

### Blue Ribbon Panel Review of NHGRI Intramural Research Program

#### Initial Meeting

January 19 - 20, 2012  
NIH Campus  
Building 31, Room 4B31

#### Thursday, January 19

8:00 am	Breakfast (Building 31, Room 4B31)	
8:30 am	Welcome and Overview <i>(15 min presentation each)</i>	Eric Green Michael Gottesman
9:00 am	The NHGRI Intramural Research Program: Past, Present, Future <i>(60 min presentation, 30 min discussion)</i>	Dan Kastner
10:30 am	Break	
11:00 am	NHGRI Clinical Research Program <i>(30 min presentation, 15 min discussion)</i>	Bill Gahl
11:45 am	Working Lunch and Executive Session	
1:00 pm	Group Discussion with Intramural Branch Chiefs <i>(60 min)</i>	All Chiefs, Bill Gahl
2:00 pm	Guided walks to 'Field Trip' Sites	

2:15 pm

'Field Trips'

**1. Building 49: Tour of Laboratories and Meet with Trainees**

Blue Ribbon Panel Members: Nancy Cox & Rick Myers

(Paul Liu and Dave Bodine will walk them to 49 and give the lab tour. Prina Laric from ITO will be the coordinator of the trainee meeting. Paul will bring them back to 31.)

2:15 - 2:45 pm: Tour labs and cores (mouse, FACS, cytogenetic, and zebrafish)

2:45 - 4:00 pm: Meet with trainees (~2 per Branch; Room 4A46)

**2. NIH Clinical Center: Tour Clinical Center and Meet with Clinical and Social Science Investigators**

Blue Ribbon Panel Members: Bruce Korf & Wylie Burke

(Dan Kastner and Bill Gahl will walk them to Clinical Center and give them the tour. Cyndi Tifft will be the lead person for the clinical faculty meeting. Dan will bring them back to 31.)

2:15 – 3:00 pm: Tour clinics, wards, and labs

3:00 - 4:00 pm: Meet with clinical and social science investigators (Les Biesecker, Max Muenke, Colleen McBride, Ellen Sidransky, Julie Segre, Laura Koehly, Fabio Candotti, Chuck Venditti, Phil Shaw, Barbara Biesecker, Cyndi Tifft, Susan Persky, Vance Bonham, Peter McGuire; Room CRC 4-2610)

**3. Building 50: Tour of Labs and Meet with Investigators**

Blue Ribbon Panel Members: David Page & Robert Waterston

(Elaine Ostrander will walk them to 50 and give the lab tour, together with Shawn Burgess. Pam Schwartzberg will be the lead person at the investigators meeting. Chandra will walk them back to 31.)

2:15 - 2:45 pm: Tour labs and cores (bioinformatics and microarray)

2:45 - 4:00 pm: Meet with Investigators (Shawn Burgess, Laura Elnitski, Daphne Bell, Nigel Crawford, Yardena Samuels, Charles Rotimi, KJ Myung, Bill Pavan, Pam Schwartzberg, Yingzi Yang, Andy Baxevanis, Marjan Huizing, Settara Chandrasekharappa; Room 5328).

4:00 pm

Guided walks to Building 31 (Paul from 49; Dan from CC; Andy and Chandra from 50)

4:15 pm

NHGRI Intramural Cores, NIH Intramural Sequencing Center, and NHGRI Animal Research Program

Paul Liu

Jim Mullikin

Core Directors

Shelley Hoogstraten-Miller

5:15 pm

Return to Hotel

6:00 – 9:00 pm Group Dinner and Executive Session

**Friday, January 20**

8:00 am	Breakfast (Building 31, Room 4B31)	
8:30 am	NHGRI Research Training Programs <i>(20 min presentation, 20 min discussion)</i>	Bill Pavan
9:10 am	NHGRI Clinical Training Programs <i>(20 min presentation, 20 min discussion)</i>	Max Muenke
9:50 am	Break	
10:00 am	Selected Scientific Presentations (4 total) <i>(20 min presentations, 10 minute discussion)</i>	Charles Rotimi Yingzi Yang Chuck Venditti Yardena Samuels
12:00 pm	Working Lunch and Executive Session	
1:00 pm	Discussion: Initial Impressions and Next Steps	Eric Green Dan Kastner Paul Liu
2:00 pm	Adjourn and Departures	

## Appendix 3

### Blue Ribbon Panel Review of NHGRI Intramural Research Program

#### Final Meeting

July 26-27, 2012  
NIH Campus  
Building 31, Room 4B31

#### AGENDA

##### Thursday, July 26

- |                |   |             |
|----------------|---|-------------|
| 9:00 am        | Update on Action Items from April BRP Teleconference  | Dan Kastner |
| 11:00 am       | Contrast between Extramural and Intramural Research Programs:<br>Open Discussion  |             |
| 12:00 pm       | Working Lunch and Executive Session<br>Travel to Building 10, Lipsett Amphitheater  |             |
| 1:00 pm        | Meet with NHGRI Intramural Faculty  | All Faculty |
| 3:00 pm        | Return to Building 31   |             |
| 3:30 pm        | Meet with select Institute Directors and Scientific Directors<br>to discuss the NHGRI Intramural Research Program's contributions to<br>the broader NIH Intramural Research Program |             |
| 4:30 pm        | Return to Hotel   |             |
| 6:00 – 9:00 pm | Group Dinner  |             |

##### Friday, July 27

- |          |                                      |                                       |
|----------|--------------------------------------|---------------------------------------|
| 8:30 am  | Executive Session and Report Writing |                                       |
| 11:00 am | Discussion: Final Conclusions        | Eric Green<br>Dan Kastner<br>Paul Liu |
| 12:00 pm | Lunch                                |                                       |
| 1:00 pm  | Adjourn and Departures               |                                       |

## Appendix 4

### The NHGRI Intramural Research Program: *E Pluribus Unum*

The overarching goal of the Intramural Research Program (IRP) of the National Human Genome Research Institute (NHGRI) is to lead the way on the NIH campus with innovative research into the genetics, genomics, pathophysiology, and treatment of human disease, leading to a deeper understanding of human biology. The NHGRI IRP plays a major role in driving the Institute's vision for the future of genomic medicine, as articulated most recently in *Nature* (Green et al., 2011). The NHGRI IRP strives to make substantive advances in three of the described research domains: understanding the biology of genomes, understanding the biology of disease, and advancing the science of medicine. The NHGRI IRP will also continue its significant contributions to all three of the cross-cutting elements described in the vision for the future of genomics: bioinformatics and computational biology, education and training, and genomics and society.

We are committed to perform studies that change the way the world understands genetics, genomics, and biomedical science. We aim to make discoveries that change the way research is conducted and the way medicine is practiced. The Faculty of the NHGRI IRP recognizes that there are important synergies among basic research, clinical investigation, and their implications for societal benefit. Maximal productivity and scientific impact requires excellence in all three areas of investigation, and collaboration results in a whole that is far greater than the sum of its parts. We aim to translate and implement findings in areas of significance in genetics, genomics, and genomic medicine.

The NHGRI IRP effectively capitalizes on the unique strengths of the broader NIH Intramural environment. Our relatively stable funding and largely retrospective review process has allowed for the initiation of long-term, high-risk, high-reward projects, a model to which we pledge to adhere. Similarly, the specialized research resources and extensive intellectual capital within the broader NIH IRP provides unparalleled opportunities for pursuing distinctive research. In return, we will continue to catalyze cutting edge genetics and genomics in all of the Institutes.

To achieve its goals, the NHGRI IRP aims to exploit its strengths in advanced technologies, basic science, and clinical investigation, integrating these capabilities with biostatistical and computational methods, social and behavioral studies, and the mentoring of a broad spectrum of trainees. Through these efforts, we will advance genetics and genomics research within our own laboratories and clinics, throughout the entire NIH IRP, and in the greater scientific community. To foster excellence across the full portfolio of the NHGRI IRP, the IRP will make use of the rigorous external review and advice provided by our Board of Scientific Counselors to allocate its resources, ensuring that individual investigators have the maximal flexibility to pursue their most compelling research goals.

While maintaining our unwavering commitment to research excellence across a broad spectrum of scientific pursuits, we see four areas as the foundation of the NHGRI IRP's goal of extending its leadership in genetics and genomics during the next decade.

- 1) **Developing and implementing state-of-the-art genomics technologies and analytical tools and disseminating these capabilities to the broader research community.** Since its inception within the then National Center for Human Genome Research (NCHGR) in 1993, the NHGRI IRP has had

an enviable and much-appreciated track record of developing and disseminating expertise in genetics, genomics, and genomic medicine not only within its own laboratories, but also the Intramural Programs of other NIH Institutes and Centers. One of these endeavors has been the advancement of genome sequencing and its many applications, with a goal not simply to produce sequence data, but to produce the infrastructure required to bring sequence to biology and medicine. The NIH Intramural Sequencing Center (NISC) and multiple investigators across the NHGRI IRP are developing novel methods to analyze genomics data with applicability to clinical and basic science questions that were thought to be insoluble only a few years ago. The NHGRI IRP has also served as the incubator for several recent initiatives in genome technology, such as the NIH Chemical Genomics Center and the NIH RNAi Screening Facility, which are now widely accessed and have become administratively independent of NHGRI.

- 2) **Conducting genetic and genomic studies with human subjects where the research has direct applications to improve the diagnosis, prevention, and treatment of disease, with an ultimate goal of developing a new molecular genetic taxonomy of human disease.** The NIH Clinical Center is the largest hospital dedicated solely to research in the world, and capitalizing on this unique resource is central to the vision of the NHGRI IRP. The Clinical Center allows NHGRI IRP investigators to deeply phenotype cohorts of patients with rare and neglected, scientifically illustrative illnesses. The Undiagnosed Diseases Program, conceived and cultivated by the NHGRI IRP and enabled by the Clinical Center, stands as a model for investigating even the rarest of diseases, a model that will soon be exported through the NIH Common Fund to multiple extramural centers. The NHGRI IRP also studies cohorts of patients suffering from common illnesses with an apparent genetic contribution and a significant public health impact, including those affecting minority populations. The NHGRI IRP will continue its pioneering work on how social and behavioral factors influence the application of genetics and genomics to promote human health, as well as the challenges of informed consent in research and the return of genomic information in the medical setting. NHGRI clinical investigators will look for opportunities to develop, test, and evaluate targeted treatment and prevention strategies for diseases under study. For example, the NHGRI IRP is currently directing and developing gene-based therapies for inherited immunologic and biochemical diseases, and will continue to provide an important leadership role in gene therapy.
- 3) **Advancing basic science by building upon the established strengths of the NHGRI IRP and capitalizing on compelling new scientific opportunities in genetics and genomics.** Some of the most clinically important discoveries occur in basic research laboratories. The NHGRI IRP is committed to a vigorous and vibrant basic science research portfolio. The NHGRI IRP regards the collaboration and synergy between laboratory- and clinically-oriented research groups as an important component of the NHGRI IRP culture. There will continue to be a significant commitment to support our basic research programs that are investigating, for example, signaling pathways in developmental biology, regulation of the immune system, basic cell biology, and genome function in model organisms including mouse, dog, and zebrafish.
- 4) **Training the next generation of researchers in genetics, genomics, and genomic medicine.** Through its many pre- and postdoctoral training opportunities coordinated by a highly supportive Intramural Training Office, its multiple accredited training programs in medical genetics and related disciplines, and its unique Genetic Counseling Training Program, the NHGRI IRP is having a broad impact within and far beyond the NIH campus. These programs will

continue to be vigorously supported. In addition, a new training program in bioinformatics will be established; the goal of this program will be to create a cadre of analysts who can disseminate expertise regarding next-generation sequencing and bioinformatics analyses within the NHGRI Intramural community, as well as populate laboratories in the broader NIH IRP, and the extramural community.

Through our commitment to innovation, scientific excellence, and collegiality articulated in this document, the NHGRI IRP will maintain its leadership role in genomic medicine through the next decade. Currently we have built a program that provides robust opportunities to integrate genome technology, clinical investigation, and basic science. On the horizon, our challenge resides not only in the full exploitation of these opportunities, but in blazing this trail for the broader biomedical research enterprise.