# Basic Research Considerations for NINDS

# Analysis and Recommendations

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# Executive Summary

Discovery science represents the wellspring for progress in biomedical science and thus the hope for future scientific breakthroughs and durable cures for neurological diseases. Discovery, or “basic”, science can be viewed as the base of a pyramid that leads upward from discoveries in fundamental processes through translational and clinical research that impact the burden of neurological disease. Although the interaction between basic science and clinical application can, and should be a dynamic two-way interaction, it cannot be overemphasized that the pathway from basic discovery to therapeutic success is not simply a pipeline that is easily engineered. Rather this pathway can be an indirect, unpredictable, even serendipitous, maze whose navigation depends on the creativity, innovation and innate curiosity of highly trained scientists. Although there has been remarkable progress in our understanding of the brain and neurological disorders, the unknowns and roadblocks remain daunting. At the same time, the opportunities created by NINDS-supported new knowledge, new technology, and a well-trained workforce are immense. A balance of basic, translational, and clinical research are essential for the success of the worldwide biomedical research enterprise that includes pharma, biotech, foundations that support research directed at specific diseases, as well as government – sponsored research. However each component in this enterprise has distinct strengths and mandates, and each have different commitments to basic, translational and clinical research. NINDS and other institutes and centers at NIH are the only component that has a major commitment to basic research. Thus, it is essential that support for discovery science remain the major component of the NINDS portfolio, if we are to lessen the burden of neurological disease and fulfill our obligation to future generations.

The Basic Research Advisory Panel assessed the current state of basic science in the NINDS portfolio and addressed how NINDS manages this aspect of its mission in terms of the balance of research topics supported, the funding mechanisms used, support for the development of research tools and resources, and the training of scientists and clinicians in basic and disease-related basic research. The recommendations of the Panel are separated into five categories based on these topics. The Panel first reviewed the state of basic science at NINDS with respect to balance across scientific disciplines in neuroscience. NIH defines basic research as science that does not directly involve human subjects (“clinical”) or does not involve direct testing of therapeutic or diagnostic treatments (“translational”). According to this broad definition, in 2007 70% of the NINDS portfolio was classified as basic science, although this percentage appears to have decreased in recent years. Perhaps surprising to those who might think that basic science is unrelated to disease, our analysis revealed that the NINDS basic science portfolio is evenly divided between fundamental discovery and disease-oriented research topics. The Panel did not identify major areas of unnecessary overlap with other NIH Institutes and Centers (ICs), or areas of disproportionate funding. To analyze the range of topics covered in the NINDS portfolio, we tested a novel algorithm for text mining that allows dynamic monitoring of the research portfolio and identification of research across disease boundaries and across NIH Institutes and Centers. We believe such tools should be further developed to allow the most efficient transfer of basic discoveries into opportunities for translational research and clinical treatments.

The Panel recognized the remarkable track record of NINDS-supported research that has contributed to several Nobel Prizes as well as to current and promising treatments for neurological disease. We view this success as a direct result of the long-term commitment of NINDS to the support of basic and disease-oriented basic research. However, we were most concerned by the gradual erosion of NINDS funding for investigator-initiated basic research R01

grants over the past 5 years. The Panel unequivocally viewed the R01 as the best mechanism for the majority of basic research support. However, our analysis suggested that the decrease in R01 grants, was disproportionate compared to other components of the Institute budget. We think this is likely to reflect a more general decline in support for basic research at NINDS. This decline puts at risk the long-term success of the NINDS portfolio. Thus, we strongly recommend that NINDS act decisively to stabilize funding for investigator-initiated R01 research and for basic science. We make several recommendations that may address this major concern in the short-term, but some recommendations involve hard choices that will require better measures to assess outcomes for wise prospective decision-making. Our analysis also suggested that NINDS must develop better measures to evaluate the effectiveness of NINDS-funded research resources and training.

Perhaps, most important of all, the NINDS must take the lead in increasing public understanding of science and the role of NIH in its development. The Panel urges NINDS to take a more active role in educating the public with respect to the results of basic neuroscience research and its implications for neurological disease. The health research enterprise, which also includes pharmaceutical and biotech private entities, is mostly dependent on NIH for basic research funding. The public should be made aware of NIH's unique role in the development of health advances. We advocate innovative methods that target the average citizen (e.g. podcasts, TV and internet) to develop educational and entertaining materials that make the public aware and involved in how science relates to their daily lives. These messages should be simple and focused and targeted to the average citizen. This approach complements more complete information that is already available from public resources such as newspapers, public television, PubMed, NINDS websites, Clinicaltrials.gov, etc. We encourage collaboration with appropriate societies and foundations such as the Society for Neuroscience and the Dana Alliance to facilitate these efforts.

Our recommendations and report are organized around the five major topics that were evaluated by the Panel (support for basic research, portfolio balance, use of funding mechanisms, research resources, and training and career development). Table 1 lists all of the recommendations and indicates the page number for the beginning of the section addressing each recommendation. Chapters I-V contain the recommendations and supporting comments and data. Throughout the report, recommendations are highlighted in boxes.

Table 1. Basic Panel Recommendations

| Rec. # | FINDINGS AND RECOMMENDATIONS | Page |
|---|---|---|
| | ***I. NINDS Support for Basic Research*** | |
| 1.1 | The Advisory Panel applauds and strongly supports the broad range of basic science that has been funded by NINDS. | 9 |
| 1.2 | Basic neuroscience research is essential to the long-term mission of the institute, and thus NINDS must continue to devote a majority of its budget to that effort. | 9 |
| 1.3 | The public has an insufficient understanding of the health-related and economic value of discovery science, thus NINDS must increase efforts to educate the public about the neurosciences. | 11 |
| | ***II. Balance of the NINDS Basic Research Portfolio*** | |
| 2.1 | Based on our analysis of balance across subfields of neuroscience, NINDS currently supports the full range of sub-disciplines within neuroscience. | 12 |
| 2.2 | The Panel supports further exploration of tools such as Topic Modeling to provide rapid | 12 |

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| | assessment and application of basic science findings to disease-oriented, translational and clinical research | |
| 2.3 | The Panel strongly supports the proven success of the R01 as the primary mechanism to drive basic discoveries in the neurosciences | 14 |
| 2.4 | The Panel strongly supports continued efforts to facilitate interdisciplinary approaches and collaborative efforts with other ICs. | 14 |
| | ***III. Funding Mechanisms*** | |
| 3.1 | At least 70% of the NINDS extramural budget should be devoted to investigator-initiated research projects (R01s) that are peer-reviewed at CSR study sections. | 16 |
| 3.2 | The Panel recommends elimination of the P01 funding mechanism | 17 |
| 3.3 | The Panel recommends that the R03 funding mechanism be increased from 50K to 100K per year and be used to support small, exploratory or pilot projects. NINDS staff should monitor outcomes of all exploratory awards in order to refine this funding mechanism. | 18 |
| 3.4 | The R21 funding mechanism does not serve its original purpose and should be eliminated | 18 |
| 3.5 | The rationale for the increase in U01 awards needs further investigation and justification | 19 |
| | ***IV. Research Resources*** | |
| 4.1 | The Panel recommends that a set fraction of the total institute budget, decided in advance and reviewed every 3 years, be devoted to resources | 21 |
| 4.2 | To qualify for institute support, resources should (a) involve complex technologies or material collections that are otherwise not readily available, and (b) for which there is broad agreement that their use will advance the field. | 21 |
| 4.3 | Given budget pressures, decisions as to which of the deserving resources to fund must be made according to consistent and stringent criteria including:<br>**a)** NINDS-funded investigators and a cross-section of other neuroscientists should be polled every 2-3 years to assess need<br>**b)** Resources should not be funded if they are readily available through the private sector, or could be made available more efficiently and less expensively through the private sector.<br>**c)** NINDS should take advantage of the opportunity to partner with other ICs, Roadmap, Common Fund, advocacy groups, foundations, biotech etc | 21 |
| 4.4 | The Panel recommends that NINDS increase oversight and assessment of its research resources:<br>**a)** Resources would be best handled with U mechanisms and year-to-year performance checks that are tied to usage and/or benchmarks.<br>**b)** Funding of tool-building projects should be accompanied by the expectation that these will be completed, and support terminated, at the end of 5 years. Facilities or services supported by this mechanism should become self-sufficient in that time period such that investigators pay market value for their use. Exceptions would be considered, but should be rare.<br>**c)** The SBIR mechanism may provide an alternative to sun-setting of support for research resources that can sustain a business plan and continue to meet the original criteria<br>**d)** Each resource must have outcome measures defined at the start and evaluated yearly. If benchmarks or performance measures are not met for 2 consecutive years, termination should be considered.<br>**e)** For facilities and collections, usage must be surveyed regularly. Resources may be judged successful either if they provide exceptional service to a small group of cutting-edge investigators or if they are broadly used by a large number of investigators.<br>**f)** Each resource must have an advisory board that meets (electronically or in person) regularly | 22 |

| Rec. # | FINDINGS AND RECOMMENDATIONS | Page |
|---|---|---|
| | **g)** P30 cores serve a different purpose, and thus should be judged by different criteria than other resources, albeit no less stringently. | |
| 4.5 | NINDS must enhance its outreach to the scientific community regarding research resources:<br>**a)** We recommend that NINDS send a yearly email to all NINDS-funded investigators summarizing research resource opportunities and providing links to more detailed information<br>**b)** We recommend that NINDS provide support for well-justified travel grants to enable researchers to acquire expert training in labs that oversee shared facilities or have specialized knowledge | 23 |
| | ***V. Training*** | |
| 5.1 | In general the Advisory Panel thinks that the training program in basic and disease-related basic research is a good investment and represents a critical component of the portfolio that should be expanded as resources allow. | 24 |
| 5.2 | The Panel is particularly supportive of T32 training programs for predoctoral students because, compared to individual fellowship awards, they provide a broader programmatic and educational environment. | 25 |
| 5.3 | The Advisory Panel recommends that NINDS training support might be more effectively invested in later-stage predoctoral rather than postdoctoral T32 programs. | 25 |
| 5.4 | NINDS currently provides sufficient support for early stage predoctoral training through the Jointly-Sponsored Neuroscience Training Program. Therefore, it is not in the best interest of NINDS to significantly expand its current investment in broad early stage (1$^{st}$-year) training programs. | 25 |
| 5.5 | The Panel thought that predoctoral students in their 2$^{nd}$ or 3$^{rd}$ year, and thus beginning specific thesis research, are relatively underserved by current NINDS training programs. The development of small (3-6 students) T32 training grants by NINDS for students at this stage would provide a synergistic and supportive academic environment larger than that provided by a single laboratory. | 25 |
| 5.6 | The Panel supports focused training programs that are oriented toward the goals of NINDS including cohesive environments that foster research in basic and translation research. | 25 |
| 5.7 | We think the T32 application process is unnecessarily cumbersome and would be improved by a more streamlined application. The Panel realizes that recent policy modifications have been put into place and that some procedures are NIH-wide, but we urge close monitoring to optimize the process. | 25 |
| 5.8 | The F32 program was considered to be successful, although accurate outcome measures are needed. | 28 |
| 5.9 | The K award programs for clinicians are well represented in the portfolio. We think that PhDs are an underutilized resource for disease-related research, thus NINDS should consider developing this type of training program for PhDs. | 28 |
| 5.10 | The K99/R00 mechanism was widely acknowledged to be working well and should be maintained. If outcomes continue to show this program is effective the Panel recommends its expansion. | 28 |
| 5.11 | Outcome measures must be developed and applied to be in line with each individual training program. | 28 |

# Panel Charge and Report Process

## A. Charge

NINDS requested that the Advisory Panel for Basic Research review the current level and nature of NINDS investments in basic research and offer recommendations for setting priorities and pursuing strategies to maximize opportunities in support of the Institute's mission. Some of the broad topics the Panel was asked to consider included:

- The balance of basic research in different areas of neuroscience
- Specific roles for NINDS funding within the context of other NIH neuroscience institutes.
- Recommendations for optimizing support for basic research, including funding mechanisms, review policies, training, and shared resources

The Panel was asked to develop specific sets of questions regarding current NINDS activities and priorities in conjunction with an internal NINDS working group, and to determine the data to be collected for addressing these questions. Furthermore, the Panel was exhorted to think creatively and broadly but also pragmatically, considering ways that NINDS can best leverage available resources.

## B. Process

Panel members were selected, appointed, and charged by the NINDS Director, Dr. Story Landis. The Panel was composed of academic and industry researchers, representing a diverse set of basic neurobiology research fields, career stages, institution types, and geographic locations. An internal working group of NINDS staff was also convened to assist the Panel in gathering data and answering any questions they might have about NIH or NINDS policies and actions.

On June 20th, 2008 the Panel met for the first time to review background information about the budget of NINDS, its funding processes and research priorities, the scientific distribution of neuroscience research topics across NINDS and other neuroscience Institutes, and the mechanisms that NINDS employs to support research resources and training and career development programs. NINDS staff was on hand to provide insight and answer any questions the Panel might have.

Following this first meeting, four Panel subgroups were created to examine in more detail the following topics:

- Research balance, including the role of NINDS in basic research as well as the balance of the scientific portfolio
- Use of funding mechanisms
- Support and oversight for research resources
- Initiatives to provide training and career development opportunities

Each subgroup requested and reviewed additional NINDS data, and developed a set of recommendations. All the subgroup recommendations were shared and discussed with the entire Panel during a closed meeting on November 16$^{th}$, 2008, when a final set of recommendations was developed. This report is a summary of the Panel's findings and recommendations with respect to how NINDS can best support basic research in the service of the Institute's mission.

# FINDINGS AND RECOMMENDATIONS:

# I. NINDS Support for Basic Research

## A. Definition of Basic Research

Of the ~$4.8 billion in funding for neuroscience research at NIH, NINDS contributes nearly a third, which is the largest portion funded by any NIH Institute (for details, see **Appendix I-A**). A majority of this research is defined by the NIH as "Basic," insofar as it does not involve research on human subjects, and is devoted to discovery of biological processes and/or disease mechanisms. Because the Panel took this NIH definition as its starting point for analysis and recommendations, it is worth emphasizing the kinds of research that are categorized as "Basic" under this definition.

Using the NIH definition, Basic Research includes:

a) Discovery based research on the normal functions of the nervous system, and

b) "Disease-related" basic research, which itself includes research on disease mechanisms, and research that derives its primary rationale from diseases (e.g., research on normal functions of disease causing genes).

Under this definition, Basic Research excludes:

a) All research on potentially identifiable human subjects (e.g., clinical trials)

b) Therapeutic and/or diagnostic development.

The Panel noted that this definition of Basic Research includes a large amount of work on disease mechanisms that is often considered "translational research," but which is not directly aimed at developing specific therapies, and instead is oriented towards discovery of pathological processes. Using new approaches to assess the NINDS research portfolio (described below), the Panel found that Institute's allocations are split roughly equally between discovery-based research on normal nervous system function vs. disease related Basic Research. This result emphasizes an important issue because it indicates that the NINDS investment in neurological disease research is by no means limited to the translational and clinical research categories. This issue seems to be often misunderstood by the public and public officials.

**1.1 The Advisory Panel applauds and strongly supports the broad range of basic science that has been funded by NINDS.**

## B. A Unique Role for NINDS within the Biomedical Research Enterprise

It cannot be overemphasized that the proportion dedicated by the federal government to biomedical research and development is far too low to ensure that we make progress toward the long term goal of reducing the burden of neurological disease The Unites States expended nearly 2.2 trillion on health care in 2007, or 16% of the GDP, 754 billion of which was spent by

the Federal government[1]. The NIH budget during this year was 30 billion[2]: 1.36% of the total health care expenditures or 4% of Federal spending. This research investment equals $103.36 per person per year.

Basic science forms the foundation of new breakthroughs, and is disproportionately supported by NIH compared to other entities such as biotech or big pharma. It is abundantly clear that breakthroughs in science and medicine are often driven by technology which requires large expenditures if we expect to obtain more than marginal therapies for devastating neurological diseases. These relationships for neuroscience research have recently been published and show similar proportions in neuroscience research[3]. Thus the NIH/NINDS budget is not sufficient to allow a creative, innovative approach to the long term problems created by neurological diseases. If we underfund research now, future generations will certainly pay a heavy price for our shortsighted view of what constitutes a health American population.

As discussed in the Funding section of this report, the case can be made that NINDS is in the direst situation of any NIH institute in that support for the backbone of basic science research, the R01 grant, has been gradually eroded, such that in 2007 only 3% of first submissions of investigator-initiated R01 grants were funded by NINDS[4]. This level of funding does not allow the country to maintain the manpower and infrastructure for basic neuroscience research, let alone recruit new expertise to the field.

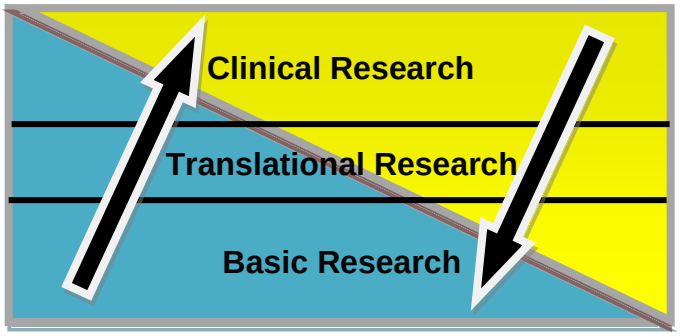



**Figure 1. Research Pipeline between NIH and Pharma/Biotech**

As shown schematically in Figure 1, a healthy research enterprise involves shared information and approaches between federal support from NIH (blue) and industry including pharma and biotech (yellow). NIH support for basic science is most crucial at the basic end of the scientific spectrum (bottom of diagram) and provides the infrastructure for discoveries in industry. Likewise, translational and clinical results from both NIH and industry can themselves provide clues to new discoveries in basic sciences. This is the traditional idea of bench-to-bedside and bedside-to-bench approach to science. However, this process must be seen as a global enterprise with NIH necessarily providing most support for basic science which requires a long-term investment, not the short-term goals that drive research in commercial and industrial settings. A reduction of basic science research in favor of translational studies without the benefit of underlying basic science, while politically popular, will negatively impact our ability to develop lasting clinical treatments. Recent examples of this problem include the failure of the

[1] Data from the National Health Expenditure Accounts (NHEA), Office of the Actuary, Centers for Medicare and Medicaid Services. See http://www.cms.hhs.gov/NationalHealthExpendData/downloads/tables.pdf
[2] http://officeofbudget.od.nih.gov/UI/2008/Congressional%20Approps.pdf
[3] Dorsey ER, et. al., Financial Anatomy of Neuroscience Research, Ann Neurol, 2006; 60: 652-659.
[4] Mandell HG and Vesell ES, Declines in NIH R01 Research Grant Funding, Science, 2008; 322 (5899):189.

AIDS vaccine[5] and of neuroprotection trials in stroke and ALS[6]. These failures have led to widespread recognition that investments in basic science should precede large investments in clinical research.

**1.2 Basic neuroscience research is essential to the long-term mission of the institute, and thus NINDS must continue to devote a majority of its budget to that effort.**

## C. Outreach and Education about the Importance of Basic Neuroscience Research

As a public agency, NIH and the NINDS have a responsibility to inform the public of the need for basic research in order to address health care issues including neurological diseases. The excitement of the discovery process can be helpful in engaging the public, but we must also educate the public in the link between discoveries in basic science and the later benefits in clinical care. Unfortunately the pathway between basic sciences discoveries and clinical treatments is often indirect and unpredictable for any particular observation. However, it is always the case that clinical treatments can be traced back, often decades, to a series of basic discoveries in both biomedical and physical sciences. Such links can be found in all sub-disciplines of neuroscience including cellular, molecular, developmental systems, behavioral and cognitive neuroscience. Examples of these linkages are important information that should be available in multiple formats and venues because they provide testimony to the value of basic research in advancing health and clinical care.

Significant research discoveries are communicated to lay audiences on the NIH website (http://www.nih.gov/news/), as well as via individual Institute websites. However, beyond a few booklets explaining neuroscience basics for a K-12 level of education, few efforts exist at NIH to expressly communicate the importance of basic neuroscience research to the overall biomedical enterprise. NIH does have some efforts specifically targeted to promoting the importance of basic research in general. The National Institute of General Medical Sciences (NIGMS) provides several publications that explicitly convey the role of pure basic research in leading to health advances and explain the value of model organisms, scientific collaboration, and adequate funding. Beyond NIH, a few non-profit organizations such as the Society for Neuroscience and the Dana Foundation have activities that advocate support for basic neuroscience research. Other organizations (HHMI, AAAS, FASEB, etc) do the same for basic research in general. Many of these organizations have created partnerships with education leaders and media. A full summary of outreach activities within and beyond NIH can be found in **Appendix I-B.**

We believe that this effort cannot be fulfilled simply by official NINDS websites, but must involve efforts that are widely available and used by the average citizen – TV, radio, popular internet venues, etc. Such an effort requires dedicated resources and personnel at the institute level to insure fulfillment of this goal.

**1.3 The public has an insufficient understanding of the health-related and economic value of discovery science, thus NINDS must increase efforts to educate the public about the neurosciences.**

[5] Kaiser J, AIDS research: Review of vaccine failure prompts a return to basics, Science 320, 30 – 31, 2008
[6] Savitz SI, Fisher M, Future of neuroprotection for acute stroke: In the aftermath of the SAINT trials, Ann of Neurol; 2007, 61, 396-402.

# II. Balance of the NINDS Basic Research Portfolio

## A. Scientific Distribution of Neuroscience Research at NINDS and NIH

Discoveries in every basic sub-discipline of neuroscience, as well as contributions from other areas of biomedical research and the physical sciences, have been essential to the understanding and treatment of neurological disorders, and offer promise in many areas for future breakthroughs. A few examples include:

- *Cellular* – the function of ion channels, receptors and synaptic proteins, and their role in learning and memory, neurodevelopmental disorders such as autism, epilepsy, and neurodegenerative diseases
- *Molecular* – the discovery of the mechanisms of activity-dependent gene regulation, the identification of genes underlying familial neurodegenerative disorders, the role of microRNAs in gene regulation; identification of protein-protein interactions in cellular signaling, the molecular structure of membrane proteins
- *Developmental* – the identification of transcription factors and other molecules involved in specification of the nervous system and its cell types, synaptogenesis, migration, and axonal pathfinding,
- *Systems* – organization of networks, pathways involved in movement, sensation, sensorimotor integration, mechanisms of perception and attention
- *Neurotechniques* – ion channel recording methods, cell-specific labeling and silencing methods, MRI, fMRI, novel approaches to gene knockout, viral-mediated gene transfer for experimental and potential therapeutics.

This list does not represent even the tip of the iceberg in terms of sub-disciplines or examples. The important point is that essentially all progress at the translational and clinical level can be traced back to a large network of discoveries in the basic sciences. Although the purpose of this report is not to document such examples, the Panel thinks that it would be worthwhile for NINDS to invest more effort to provide such examples as part of a general program to support public education. The Society for Neuroscience has made several efforts in this direction, but more is needed.

- Brain research success stories: A series of publications detailing research into neurological and psychiatric disorders http://www.sfn.org/index.aspx?pagename=brainResearchSuccessStories
- Brain Briefings: A monthly two-page newsletter explaining how basic neuroscience discoveries lead to clinical applications http://www.sfn.org/index.aspx?pagename=brainbriefings_main

A major task of the panel was to assess the balance in the NINDS basic research portfolio. We soon realized that this was not a simple task with the information available. Thus we developed several new approaches to more accurately assess the research topics that are supported by NINDS and whether there were areas of unnecessary overlap with other institutes within NIH; and more generally in the global contribution of basic research support for the neurosciences that includes private foundations, industry and other countries. About 10 years ago, the NINDS program was organized in “Clusters” that are used to manage the grants portfolio. Most NINDS grants are assigned to one of six Clusters, which consist of teams of Program Directors and associated staff (see **Appendix II-A**). Although the clusters are organized around scientific and disease categories, NINDS Program Clusters integrate various kinds of research, and incorporate idiosyncrasies as a result of staff expertise, and therefore does not easily translated into a coherent analysis of the Basic Research portfolio.

As an alternative framework, the Panel approved an NINDS staff effort in which the NINDS grants portfolio was binned according major themes used by the Society for Neuroscience (SfN) to categorize abstracts submitted to their annual meeting, and for work published in the *Journal of Neuroscience* (see **Appendix II-B**). The advantage of this strategy is that the framework provides a comprehensive categorization system with readily recognizable, broad categories. In order to validate the relevance of this approach, staff also obtained quantitative data regarding NIH Institute funding for individual Society for Neuroscience abstracts. The proportion of grants that binned into SfN categories closely matched NIH/NINDS support for SfN abstracts, indicating that this method provided a reliable means to assess scientific activity in NINDS-funded research. Thus the Panel agreed that these data provided reasonable representations of relative support by different NIH Institutes to different neuroscience research categories. The Panel used these data to assess how resources have been allocated and to see what deficiencies and opportunities might exist.

The analysis revealed that NINDS resources are distributed across basic science disciplines in ratio comparable to SfN abstracts. In other words, NINDS support for basic neuroscience is well matched to the distribution of activity and expertise in neuroscience. Based on internal referral guidelines used by NIH to assign grants to various institutes, support was consistent with the Institute's focus on neurological diseases. For example, NIMH and NIDA/NIAAA appropriately supported more basic research relevant to mental health or addictive disorders. Thus the Panel found no evidence of unnecessary overlap with neuroscience supported by other ICs. Rather there were multiple indicators of collaborations, both formal and informal between ICs such as the Neuroscience Blueprint.

**2.1 Based on our analysis of balance across subfields of neuroscience, NINDS currently supports the full range of sub-disciplines within neuroscience.**

In addition to use of the Society for Neuroscience categories as a framework for analysis of the NINDS research portfolio, the Panel also undertook an informatics approach (Topic Modeling) using statistical analysis of grant titles and abstracts to develop an unbiased assessment of Institute-funded research. NINDS staff contracted a team of specialists who were willing, in a short time-frame and with limited funding, to apply text-mining and visualization tools to a set of NINDS grants in order to test their potential utility for grants analysis.

The result is available to the public (http://www.nihmaps.org/) as an interactive map of topical relationships between NIH grants, which utilizes unsupervised statistical assessment (Latent Dirichlet Allocation) of the language used by investigators to describe their research. The essence of the approach is that the analysis is used to develop a set of topics, rather than the traditional method of assigning grants to pre-assigned topic categories. The topical relatedness of grants can then be viewed graphically on an interactive map using a Google Maps format. This dynamic and interactive approach provides an intuitive framework from which one can probe for additional information (e.g., color-coding of individual ICs) and access locally similar grants within a global, comprehensive framework. This prototype has been developed in the spirit of academic openness, using open source code, published algorithms, and data on NIH grants that is available to the public. This tool is a unique resource that provides grants analysis capabilities not otherwise available to NIH staff or to the public, and NINDS is currently exploring funding avenues for enhancing its functionality and making it more widely available. It also does not suffer the limitations of any database or website in that Topic Modeling approach is dynamic and can be probed instantaneously by anyone including Program staff, NIH scientists, the public, or even by an Institute Director sitting with a congressional staffer or a patient advocacy group. This approach has educational and political value in demonstrating that

basic mechanisms (and breakthroughs) cross disease boundaries, and also has practical value for program staff in assessing portfolio balance and forming collaborations with other institutes and funding sources.

**2.2 The Panel supports further exploration of tools such as Topic Modeling to provide rapid assessment and application of basic science findings to disease-oriented, translational and clinical research.**

## B. Determination of Institute Priorities for Basic Research

A majority of NINDS awards are investigator-initiated projects funded by virtue of their percentile score (see **Appendix II-C**). Although this portion of the Institute budget has been shrinking (see Funding Mechanisms section below) the Institute currently devotes only a small portion of its budget for Basic Research towards Institute-initiated research priorities, and instead allows the peer review system to be the primary determinant of funding. Although this approach can seem "undirected" to some that question the value of basic science, it has the immense advantage of being relatively unbiased in that investigators are driven by the state of the knowledge and technology in science, and by their own creativity and innovativeness. In the lingo of genetics, this approach represents an unbiased "forward screen" for new biology and new technology. Although it is tempting to try to predict which topics in basic science should be targeted, our view is that we will be best served by allowing individual researchers to creatively explore the workings of the brain within the framework of improving health through better understanding. The Panel was unanimous in their belief that an effort to direct basic science is not the most efficient or reliable means to achieve the mission of NINDS. This viewpoint from our perspective is well-validated by the tremendous accomplishments of the NIH over the past 60 years. Thus the Panel strongly supported continuation of investigator-initiated, peer-reviewed grant mechanisms as the best strategy for funding of basic science at NINDS. The Panel also recommends that NINDS Program Staff be equipped with better tools to track advances and to respond and facilitate discoveries in basic science and their translation, in line with the mission of NINDS. The panel was also supportive of efforts to enhance innovation and creativity of the R01 through improvements in the peer review system that are underway.

**2.3 The Panel strongly supports the proven success of the R01 as the primary mechanism to drive basic discoveries in the neurosciences.**

Progress in neuroscience depends on interdisciplinary efforts of scientists trained across the full range of biomedical and physical sciences. Thus the Panel thought that NINDS must continue to encourage work between scientific disciplines (e.g. biology, engineering, physics, math, etc) and across sub-disciplines within neuroscience (behavioral, molecular, computational, etc). Such efforts can and should take multiple forms and include funding mechanisms, research resources, training resources and trans-institute programs. The Panel also favors methods to encourage increased migration of non-neuroscientists with specific expertise (physics, math, and engineering) to neuroscience. Such efforts might involve programs developed with other federal agencies or non-federal granting agencies. Although the Panel did not explore this topic in sufficient detail to make highly specific recommendations, NINDS could take the lead in promoting an analysis of this topic with other Blueprint institutes as well as across NIH.

**2.4 The Panel strongly supports continued efforts to facilitate interdisciplinary approaches and collaborative efforts with other ICs.**

# III.Funding Mechanisms

## A. Introduction

NINDS uses a variety of grant mechanisms to fund extramural research, ranging from large Program Projects and Centers to small awards for fellowships and scientific conferences. For a description of the various grant mechanisms and their different characteristics, see http://www.ninds.nih.gov/funding/grant_mechanisms.htm. Each year, approximately one quarter of the budget is spent on competing awards. As is the case for most NIH Institutes, a majority of the NINDS extramural research budget goes to R01 mechanism grants, which are awarded to individual investigators funded by virtue of their percentile score (a description of the competing awards process is described in **Appendix II-C**).

Although NINDS received substantial increases in Congressionally-appropriated funds during the NIH budget "doubling" (between 1999 and 2003), appropriations in the past five years have remained essentially flat, and have declined when adjusted for inflation (see **Appendix III-A**). More importantly, success rates for R01 applications, the majority of which are investigator initiated projects that form the bedrock of NIH support for neuroscience, hit historic lows in 2006 and 2007.

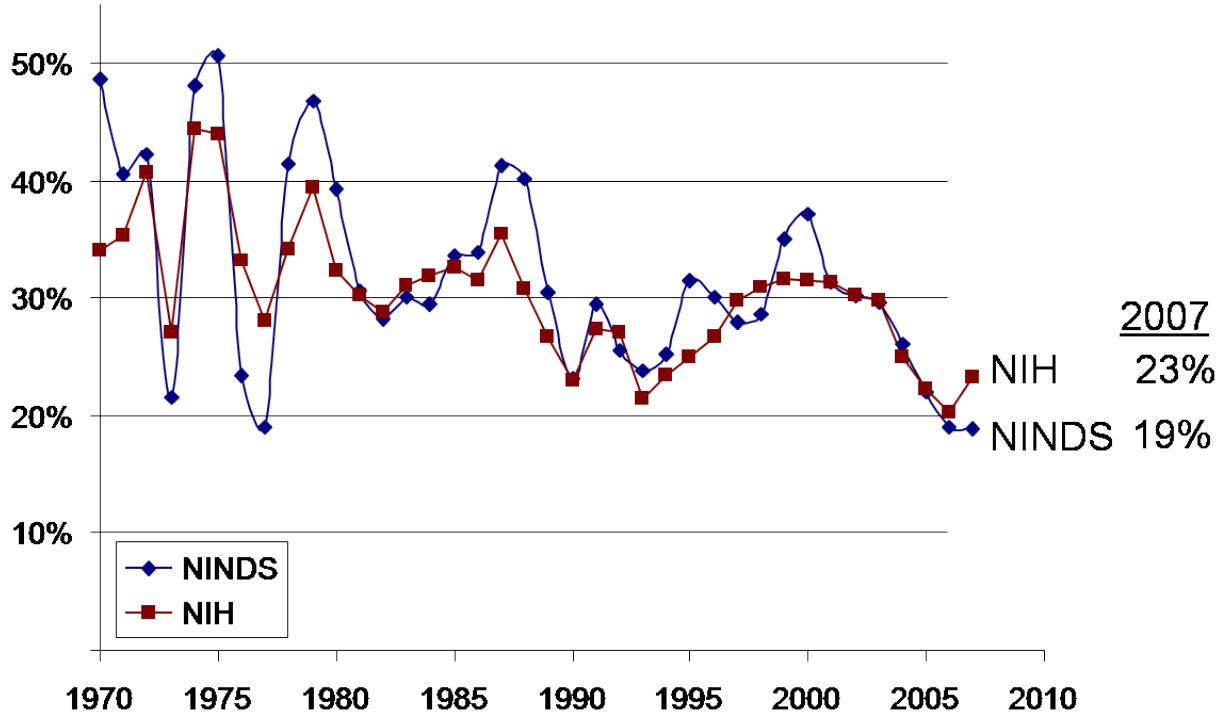



**Figure 2. R01 Success Rate Data –** Compiled from NIH OER website[7].

The panel noted this trend with alarm and asked NINDS to provide detailed information per mechanism about recent trends in the budget, number of awards, success rates, and review and funding policies.

[7] http://report.nih.gov/index.aspx?section=NIHFunding

## B. Budget, Success Rates, and Historical Trends of NINDS Mechanisms

**Appendix III-A** shows comparative data on R01 submissions and awards from NINDS and other NIH Institutes over the past five years. These data show that during this period there was a modest increase in the number of NINDS R01 submissions and a slight increase in the size of NINDS R01 awards. However, the largest contributor to the decline in success rates was a decrease in the number of awards, primarily driven by a decrease in the Institute budget for this mechanism. The following figure shows a breakdown of the extramural research budget and total number of awards for the major research funding mechanisms over a five year period. The R01 and P01 mechanisms were the only mechanisms that decreased over this time span.

| | | Number of Awards | | | | | | Total Cost (Millions) | | | | | | 5year change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | |
| RPG | R01 | 2340 | 2373 | 2260 | 2272 | 2146 | 2018 | 813.8 | 836.4 | 822.3 | 798.4 | 761.8 | 730.3 | -83.5 |
| | R03 | | 33 | 24 | 42 | 55 | 48 | 0 | 2.4 | 1.8 | 3 | 4.5 | 3.5 | 3.5 |
| | R15 | 14 | 13 | 11 | 14 | 11 | 17 | 1.9 | 2.8 | 2.5 | 3 | 2.3 | 3.6 | 1.7 |
| | R21 | 221 | 215 | 209 | 225 | 278 | 308 | 39.2 | 39.3 | 38.5 | 41.3 | 51.5 | 57.1 | 17.8 |
| | R37 | 49 | 66 | 80 | 79 | 82 | 75 | 19.7 | 27.2 | 33.8 | 33.3 | 34.6 | 34.1 | 14.3 |
| | U01 | 15 | 21 | 39 | 39 | 50 | 60 | 45.1 | 35.7 | 75.2 | 63 | 86.5 | 121 | 75.4 |
| PPGs/ Centers | P01 | 81 | 77 | 73 | 67 | 73 | 66 | 103 | 100 | 96.3 | 84.8 | 89.7 | 80.1 | -22.7 |
| | P30 | 8 | 13 | 19 | 21 | 23 | 26 | 5.2 | 8.3 | 11.8 | 14.7 | 15.5 | 17.5 | 12.4 |
| | P50 | 39 | 36 | 31 | 32 | 30 | 35 | 48 | 51.9 | 45.9 | 50.9 | 47.2 | 54 | 6 |
| | U54 | 14 | 12 | 13 | 15 | 16 | 17 | 16.3 | 12.9 | 16.9 | 22.1 | 24.9 | 24.9 | 8.6 |
| Careers | | 184 | 213 | 244 | 260 | 269 | 274 | 28.3 | 33.3 | 39.1 | 43.1 | 44.1 | 44.7 | 16.4 |
| Training | | 713 | 768 | 753 | 733 | 756 | 698 | 28.8 | 29.9 | 32.8 | 28 | 32.4 | 32 | 3.2 |
| SBIR | | 124 | 128 | 109 | 103 | 99 | 111 | 32.6 | 35.9 | 37.2 | 37 | 37.7 | 37.7 | 5.1 |
| Other | | 90 | 69 | 90 | 106 | 131 | 134 | 19.2 | 16 | 18.8 | 16.4 | 22.2 | 20.9 | 1.7 |

| | % Grants Budget | |
|---|---|---|
| | 2003 | 2008 |
| R01 | 67.5% | 57.6% |
| R03 | 0.0% | 0.3% |
| R15 | 0.2% | 0.3% |
| R21 | 3.3% | 4.5% |
| R37 | 1.6% | 2.7% |
| U01 | 3.7% | 9.5% |
| P01 | 8.5% | 6.3% |
| P30 | 0.4% | 1.4% |
| P50 | 4.0% | 4.3% |
| U54 | 1.4% | 2.0% |
| Car. | 2.3% | 3.5% |
| Train. | 2.4% | 2.5% |
| SBIR | 2.7% | 3.0% |
| Other | 1.6% | 1.6% |

**Figure 3. Five Years Trends for Major NINDS Funding Mechanisms (Source: NINDS FINeX Budget Tables)**

In 2004, 67.6% of the NINDS extramural grants budget ($836.4M) was devoted to R01s, but this fraction dropped steadily, reaching 57.6% ($730.3M) in 2008. The diversion of funds away from traditional R01s has contributed to the marked decline in the R01 success rate, which, in 2007, reached the lowest level in the history of the Institute. The Panel believes that investigator-initiated R01s with their rigorous peer review at CSR study sections are the best mechanism to identify innovative, high-impact research. The deleterious effects of this precipitous drop in the R01 success rate include: 1) a reduced ability to support innovative, high impact neuroscience research; 2) an unprecedented amount of pressure on investigators and study sections to secure and review grants; 3) a drop in morale within the scientific community; 4) reduced training support from individual laboratories, and; 5) a dramatic darkening of young investigators' perception for the prospects of a career in biomedical research. These outcomes undermine the goals of NINDS and indeed our national commitment to improving the standard of living through basic and applied research that leads to treatment and cures for neurological disorders. They also detract from our ability to train the next generation of leaders in the biomedical research community. In addition, many talented young American neuroscientists have recently taken permanent positions overseas, including in England, Germany, Switzerland, Canada, France, Italy, and Portugal, because of concerns about long-term funding and opportunity in the U.S. This brain drain must be reversed to maintain cutting-edge research and training in the U.S. The Panel recommends that the NINDS leadership take drastic measures, including those outlined in recommendations 3.2 through 3.5, to ensure that 70 % of the

extramural grants budget be devoted to support R01 research grants as the main infrastructure of the extramural research program:

**3.1 At least 70% of the NINDS extramural budget should be devoted to investigator-initiated research projects (R01s) that are peer-reviewed at CSR study sections.**

## C. Program Project Grants (P01)

The P01 mechanism provides support for teams of investigators studying different aspects of a research topic. Each project must have a minimum of three teams that work collaboratively and typically share resources, such as patient data or DNA sequencing facilities. Although very similar in terms of goals and level of support, P50 Center grants are usually focused on a specific neurological disorder and are accepted only in response to a specific funding announcement. Approximately half of the P50 awards are directed towards Congressionally-mandated initiatives. Because the P50 mechanism is reserved for directed research initiatives, the Panel focused on the P01 mechanism.

P01 applications are reviewed separately from R01s, and as shown in the following table, their success rates historically have been considerably higher than those of R01s, (as have their competitive renewal rates, see **Appendix III-B**).

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| **R01** | 29.6% | 26.1% | 22.0% | 19.0% | 18.8% | 21.7% |
| **P01** | 50.0% | 28.6% | 35.6% | 23.5% | 40.5% | 50.0% |

**Table 4. Comparison of R01 and P01 Success Rates –** Compiled from NIH OER website[8].

The exceptionally high success rates of P01 applications may reflect problems in peer-review ranking/prioritization mechanisms relative to R01 applications, as well as biases among program staff and reviewers in small panels, where anonymity of the process is compromised.

To gauge whether P01 awards are proportionally more productive than R01 projects, NINDS staff assessed the average output of each type of grant in terms of publications cited in Medline, and the relative impact of those publications, as indicated by number of citations in the Thomson/ISI database (**Appendix III-B**). Although this was a preliminary analysis, and the data should be used with caution, the analysis failed to show an aggregate difference in relative output between P01s, P50s or R01s.

Allocation of $88 million for P01 grants in fiscal year 2008 (see **Figure 3**) amounts to a substantial fraction (6.3%) of the NINDS extramural grants budget. Given concerns over review for P01s, renewal rates, and productivity:

**3.2 The Panel recommends elimination of the P01 funding mechanism.**

Although elimination of the P01 funding mechanism is likely to yield an increase in the number of R01 applications, the quality and potential for impact of these additional applications will be

[8] http://report.nih.gov/index.aspx?section=NIHFunding

funneled through CSR peer-review study sections, and their priority scores will be assigned in comparison to the larger, more diverse pool of R01 proposals. The Panel believes that existence of the multiple-PI R01 option circumvents the need for funding mechanisms geared towards collaborative, interdisciplinary projects. This change will level the playing field for evaluation of all R01-level grants in the NINDS portfolio. The Panel also emphasizes the need for continued support for research infrastructure and cores (P30s) and for research teams (multiple-PI R01 applications).

## D. Small Grants, Exploratory Grants, and Mechanisms to Promote Innovation

In addition to the R15 Academic Research Enhancement Award (which is offered to applicants from primarily baccalaureate degree granting institutions with little NIH funding), NINDS offers two grant mechanisms for small-scale research projects, the R03 and R21, which have limits of $100,000 and $275,000 in direct costs during a two year period, respectively.

For both the R03 and the R21 mechanisms, NINDS places specific restrictions on the kinds of projects that can be funded. For the R03 mechanism (which is used more broadly at NIH to support small-scale projects or for pilot or feasibility studies), NINDS limits these projects to those that "develop a defined product (e.g. animal model, database, or reagent) or data unit (e.g. microarray or proteomic analysis or pre-clinical drug screen), that are focused on secondary analysis of clinical data, or that are collecting clinical data or samples for an NINDS repository" (see http://www.ninds.nih.gov/funding/r03guidelines.htm). For the R21 mechanism, the project must be "a new avenue of investigation or of a new technology that could lead to a major breakthrough, or on proposals for research that could have a major impact in a field." Such proposals should be "truly ground-breaking", and should not offer incremental research in well-established areas of science (see http://www.ninds.nih.gov/funding/r21guidelines.htm).

In spite of these restrictions, the panel was informed that as a policy, NINDS rarely rejects proposals that are scientifically within the mission of the Institute, and that these mechanisms are often used to apply for seed money for projects that have the potential to develop into full scale investigations, but that are not at a stage where an R01 application would be competitive. In addition, substantial portions of the applications for these mechanisms are from new investigators (48.3% and 31.5% for R03 and R21 applications, respectively, in 2008), who may believe that they have a better chance at a small award than a first R01. Thus the panel agreed that these mechanisms have been inappropriately used to fund small-scale projects that lack a full complement of research aims (sometimes known as "baby-R01s").

The Panel noted that the discrepancy between Institute guidelines and actual awards creates confusion for investigators and reviewers. For the R21, this confusion is exacerbated by widely varying ways in which different NIH Institutes use the R21 mechanism, with some Institutes supporting pilot projects, feasibility studies, small-scale projects, the development of new methodology, or secondary data analysis (see http://grants.nih.gov/grants/guide/contacts/pa-06-181_contacts.htm).

It was the impression of the Panel that high-risk, high-reward research could be supported through regular R01s or through new mechanisms or initiatives. NIH has recently created additional avenues to support "high-risk, high-reward" research, including the NIH Director's Pioneer and New Innovator Award Programs (http://nihroadmap.nih.gov/), the Transformative R01 Program (http://nihroadmap.nih.gov/T-R01/), and the EUREKA R01 Program (http://grants.nih.gov/grants/guide/rfa-files/RFA-GM-09-008.html). All of these initiatives are

meant to fund ground-breaking research that may lack sufficient preliminary evidence to score highly in traditional review study sections. In addition, upcoming changes in NIH peer review and application format are also intended to shift the focus from preliminary research and methodology to questions of scientific or public health impact.

Given these developments at NIH, the Panel felt that "high-risk high-reward" research had a clearly defined base of support outside of the R21 mechanism. On the other hand, slight modification of the current NINDS R03 mechanism and guidelines could enable the support of both the currently covered types of R03 research as well as small pilot studies for which there were insufficient preliminary data.

**3.3 The Panel recommends that the R03 funding mechanism be increased from 50K to 100K per year and be used to support small, exploratory or pilot projects. NINDS staff should monitor outcomes of all exploratory awards in order to refine this funding mechanism.**

For R21 grants, NINDS criteria are: 1) to support projects that could lead to breakthroughs in a field, or to test feasibility of 2) a novel avenue of investigation or 3) new technologies. The Panel feels that these are the goals of the R01 and, in the case of feasibility, R03 funding mechanisms. With the changes we propose in this report, the R21 mechanisms will become redundant both with R01 and R03 mechanisms as well as T-R01 and EUREKA awards developed in recent years. Moreover, the R21 is not currently being used by applicants for its intended purpose to foster innovation, but instead frequently functions as a "baby R01," either for investigators with insufficient preliminary data or for new investigators who fail to obtain R01 funding (in part because of the very low paylines) and who retreat to the R21 mechanism in the hope of obtaining any funding. Investigators who have preliminary findings to support the potential for high-impact NINDS-funded research should submit an R01 application. Investigators with insufficient preliminary findings to support an R01 should submit an R03 application, which, as stated above, is used to fund exploratory or pilot projects.

**3.4 The R21 funding mechanism does not serve its original purpose and should be eliminated.**

## E. Other Funding Mechanisms

The Panel noted that although the R01 budget and number of awards had decreased between 2003 and 2008, the proportion of the budget and number of awards for U01s, which are cooperative research agreements used for clinical trials or translational research, had increased considerably (see **Figure 2**). There has been a substantial proliferation of translational and clinical U01 research projects supported by NINDS, from 3.7% of the 2003 grants budget to 9.5% of the 2008 budget. The proliferation of U01s appears to be one of the greatest factors in the diversion of funds away from R01s. The Panel supports the use of U01 to fund work that lends itself to completion of well-defined milestones similar to contracts, and thus to periodic review and oversight by program staff. However, resources should not be diverted to the U01 mechanism if it depletes the funds that would otherwise go to investigator-initiated discovery science (R01s).

**3.5 The rationale for the increase in U01 awards needs further investigation and justification.**

# IV. Research Resources

## A. Introduction

Alone and in collaboration with other ICs and NIH Consortia such as the Neuroscience Blueprint, NINDS supports the development and dissemination of tools, technologies, and resources that may facilitate and advance neuroscience research. Brief descriptions and links to many of these resources are provided in **Appendix IV-A,** and may also be found on the NINDS website (http://www.ninds.nih.gov/research/scientific_resources/index_research.htm) or the Blueprint resources web page (http://neuroscienceblueprint.nih.gov/). NINDS researchers may also take advantage of resource development programs though the NIH Roadmap, which was designed to identify and capitalize on scientific opportunities and gaps of broad impact that no single institute could address. Roadmap programs are funded through the Office of the Director and NINDS does not contribute direct funding to participate. More information about Roadmap and its programs may be found here: (http://nihroadmap.nih.gov/)

Historically, NINDS has used a range of different funding mechanisms to support research resources, each providing different levels of oversight and involvement by program staff. Contracts are used for cases where there is a specific service or product sought and they provide the Institute the highest degree of oversight and ownership. Cooperative agreements (U24) are used in many cases to support investigator-initiated projects in response to program announcements or priorities. Cooperative agreements have special terms and conditions in addition to those that apply to grants, and entail significant involvement of NIH staff in determining objectives and implementation. Additionally, investigators may propose resource development ideas through resource-related research project grants (R24), which are similar in scope to U24s but which do not provide an additional level of oversight. For program priorities, NINDS has begun converting many of its R24 awards to the U24 mechanism. Finally, NINDS supports the establishment and maintenance of institutional research core facilities through the P30 mechanism.

NINDS participation in the Federally-mandated Small Business Innovation Research (SBIR) Grants program provides another source of support for the development of research resources that might have commercial application. The mandated SBIR set-aside is currently 2.5% of the total NINDS budget and a significant portion of these Small Business awards are devoted to developing tools and resources. For FY07, 17 out of 106 SBIR awards (Phase I or II) were deemed by program staff to be devoted to the development of tools or technologies that might have broad application. A list of these resource-developing SBIR awards is provided in **Appendix IV-B.**

The Advisory Panel requested detailed descriptions of all major NINDS research resources initiatives. NINDS Program Officers in charge of each initiative provided this information, and an NINDS working group verified the information for accuracy and completeness before sharing with the Advisory Panel.

## B. Criteria for Future Resources

The Advisory Panel found that NINDS supports the development and dissemination of several types of shared resources:

- New tools or technology that the community can use Specialized service facilities

- Data or tissue repositories or collections (such as brain banks)
- Institutional core facility centers

The Advisory Panel generally agreed that all of these resource types can be of great value to NINDS investigators and advance the mission of NINDS. Thus, **NINDS should continue to support the development and maintenance of these resources.** There also was general agreement that the need for resources can change relatively quickly in the community, either because better methods evolve or because a resource becomes available from other sources. Therefore, **NINDS needs means to reevaluate the resources it supports on a regular basis.**

After considering the objectives and use of the current resources, it was clear to the Panel that resources varied greatly in scope, degree of usage or impact on the neuroscience community, and plans for sun-setting or long-term support. The Panel decided not to make specific comments about the research tools and resources that NINDS currently supports. Rather, the Panel thought it was appropriate to discuss a set of consistent criteria that the Institute might use to determine which resources to develop or fund, how to best maintain them, and how to assess the changing technological landscape to determine when NINDS support is no longer needed or effective.

Although the panel recognizes that devoting set fractions of the budget reduces flexibility, we think that using a maximum budget for resources will allow critical decision-making in terms of which resources are most essential to the NINDS mission. This goal might also be facilitated by review of such applications only once per year by a common review group, representing the appropriate expertise.

**4.1 The panel recommends that a set fraction of the total institute budget, decided in advance and reviewed every 3 years, be devoted to resources**

A review of the descriptions of the current research resources showed a wide variety of criteria had been used by NINDS to choose resource initiatives. Several projects, such as the Coriell DNA and Cell Line Repository, Pediatric MRI, GENSAT, the Chronic Microelectrode Arrays were conceived by program staff and developed as contracts; others (e.g. KOMP, NIF, NIH Toolbox, etc) were initiated by the Neuroscience Blueprint; yet other were initiated by other ICs and NINDS subsequently decided to participate; some resources had been solicited through funding announcements; and a few were unsolicited investigator-initiated proposals. In going forward, the Panel thinks that NINDS would benefit from more consistent and stringent criteria to decide which resource initiatives were most appropriate for NINDS support.

**4.2 To qualify for institute support, resources should (a) involve complex technologies or material collections that are otherwise not readily available, and (b) for which there is broad agreement that their use will advance the field.**

**4.3 Given budget pressures, decisions as to which of the deserving resources to fund must be made according to consistent and stringent criteria including:**

**a. NINDS-funded investigators and a cross-section of other neuroscientists should be polled every 2 years to assess need.**

**b. Resources should not be funded through this mechanism if they are readily available through the private sector, or could be made available more efficiently and less expensively through the private sector.**

Several NINDS resources had been developed in partnership with other ICs or through formal collaborations such as the Blueprint. In some cases, NINDS programs also leveraged funding from private sources, the FDA or other agencies, or from professional or advocacy non-profit

organizations. The Advisory Panel was supportive of such partnerships and encourages them for future endeavors. In this regard a centralized Program direction would help in serving as a savvy clearinghouse to look for funding partners, both public and private.

**c. NINDS should take advantage of the opportunity to partner with other ICs, Roadmap, Common Fund, advocacy groups, foundations, biotech etc.**

In this regard, assigning the Research Resources portfolio to a designated program officer could help as a savvy clearinghouse to identify appropriate funding partners, both public and private.

## C. Oversight and Assessment

The resource descriptions provided by NINDS staff showed wide variability in the level and appropriateness of oversight processes and evaluation metrics. Thus,

**4.4 The Panel recommends that NINDS increase oversight and assessment of its research resources:**

A number, but not all of the NINDS research resources were funded through cooperative agreements that had defined milestones and goals that program staff could evaluate. The cooperative agreement mechanism allows funding to be contingent on the achievement of specific measures and requires increased NINDS staff involvement. Thus, the Panel deemed cooperative agreements preferable to regular grants for the development of resources. Contracts allow the highest level of staff involvement and oversight but, unlike cooperative agreements, they are not peer-reviewed and do not compete side-by-side with other proposals for resource development. Hence, the Panel judged that cooperative agreements should be the main mechanism used to support research resources.

**a. Resources would be best handled with U (Cooperative Agreement) mechanisms and year-to-year performance checks that are tied to usage and/or benchmarks.**

Most NINDS resources were initiated in the last ten years, but a couple of resources had been maintained for decades. The Panel found that NINDS does not have clear guidelines to determine how long to maintain a resource, when a program is no longer needed, or how to sunset a resource initiative.

**b. Funding of tool-building projects should be accompanied by the expectation that these will be completed, and support terminated, at the end of 5 years. Facilities or services supported by this mechanism should become self-sufficient in that time period such that investigators pay market value for their use. Exceptions would be considered, but should be rare.**

SBIR awards, which are a congressionally-mandated fraction of the budget (2.5%), provide another funding mechanism for resources. We encourage the Institute to be more proactive in soliciting SBIR proposals for the development of research resources, or suggesting that applicants consider SBIR awards as a way to develop a business plan that could sustain the resource. Particularly, funded resources which have proven to be successful, and for which there continues to be a need in the community (i.e. which are commercially viable), should take advantage of the SBIR mechanism to sustain the service or resource. This would ensure that

resources for which there is a commercial market are moved outside of NINDS to free funds for emerging technologies in their early stages.

**c. The SBIR mechanism may provide an alternative to sun-setting of support for research resources that can sustain a business plan and continue to meet original criteria.**

Evaluation criteria for NINDS resources varied, from strictly defined measures codified by a contract or a cooperative agreement, to more loosely defined measures. Popular evaluation criteria included some quantitative metrics such as publications citing the resource, usage reports, and time for completion of orders. In very few cases cost comparisons were also tracked. A small set of resource programs polled their users for their level of satisfaction with the resource or for feedback on how to improve. In terms of oversight, most resource programs had external advisory boards with NINDS representation that met on annual or bi-annual basis. The Panel thought that resources should be continuously evaluated through a set of concrete and stringent measures in order to ensure effective use of funds. One exception however, was the P30 program, which provides support for institutional core facilities. This program supports the acquisition and establishment expensive research infrastructure for the research community at an institution, but it also serves the purpose of providing training opportunities for students and postdocs and fostering partnerships and collaborations within the research community. While P30 facilities might have different outcome criteria than other resource mechanisms, Panel members agreed that these awards should also be periodically evaluated and monitored. Given these findings the Panel recommends that:

**d. Each resource must have outcome measures defined at the start and evaluated yearly. If benchmarks or performance measures are not met for 2 consecutive years, termination should be considered.**
**e. For facilities and collections, usage must be surveyed regularly. Resources may be judged successful either if they provide exceptional service to a small group of cutting-edge investigators or if they are broadly used by a large number of investigators.**
**f. Each resource must have an advisory board that meets (electronically or in person) regularly.**
**g. P30 cores serve a different purpose, and thus should be judged by different criteria than other resources, albeit no less stringently.**

## D. Resource Dissemination and Outreach to Scientific Community

Most NINDS-supported resources had websites dedicated to describing the resource, its objectives, and explaining the procedures for researchers interested in participating. NINDS and Blueprint also have websites dedicated to research resources. However, the Panel noted that investigators may not search for these resources on websites unless they already have some notion that they are available. The lack of awareness about available resources undermines the effectiveness of NINDS investments and hinders research progress. Yearly emails to NINDS grantees would provide a low-cost way of notifying them about available resources, thereby ensuring that NINDS monies are usefully spent.

In addition, the Panel considered that dissemination of technical expertise was equally important to the dissemination of tools or services. Many research techniques require focused one-on-one training (e.g. electrophysiology, optical imaging or optical manipulation techniques, tissue

preparation, translational research, etc). The Panel thought that NINDS should devote some resources to facilitate this exchange of technical information.

**4.5 NINDS must enhance its outreach to the scientific community regarding research resources:**

**a. We recommend that NINDS send a yearly email to all NINDS-funded investigators summarizing research resource opportunities and providing links to more detailed information.**

**b. We recommend that NINDS provide support for well-justified travel grants to enable researchers to acquire expert training in labs that oversee shared facilities or have specialized knowledge.**

# V. Training and Career Development

## A. Training and Career Development Support at NINDS

Our understanding of the development, structure and function of the nervous system is expanding rapidly due to the emergence of new technologies and increased investment over the last decade. Further progress in research discoveries and translation of that knowledge into the development of therapies for neurological diseases requires continued training of scientists in a range of neurological disciplines. Significant investment by NINDS in multiple training program modalities will yield substantial future returns in several ways. For example, it will ensure there is a suitably trained workforce to continue to address the outstanding challenges to the mission of NINDS. In addition, a relatively limited investment in supporting young investigators can help direct their subsequent career trajectory towards addressing the goal of NINDS. NINDS has a strong history of supporting the training of young investigators at multiple career stages. In preparing its recommendations on training, the Panel worked closely with NINDS staff and with the Director of the NINDS Training Office to evaluate data on NINDS training programs and assess areas for improvement.

Approximately $80 million[9] of the NINDS annual budget is used to directly support the training of scientists and physician scientists at various career stages. Funding mechanisms include institutional training programs (T32), pre and postdoctoral individual fellowships (F30, F31, F32), and mentored research and clinical scientist development awards ("K" series), including the recently established pathway to independence awards (K99/R00). Descriptions of each mechanism are provided in **Appendix V-A**. Budget amounts and total number of trainees per mechanism can be found in **Appendix V-B**. Total spending on training by type of award (Institutional, Individual, or Career and Development) and by NIH Institute is depicted in **Appendix V-C**. Compared to other Institutes, NINDS is in the mid-range of the scale in terms of proportion of its budget devoted to training.

[9] It should be noted that the $80 million budget figure does not capture the number of postdoctoral investigators who are supported through the R01of their principal investigator mentor. Because NIH does not track these numbers, the total budget allocated to supporting all trainees is not known.

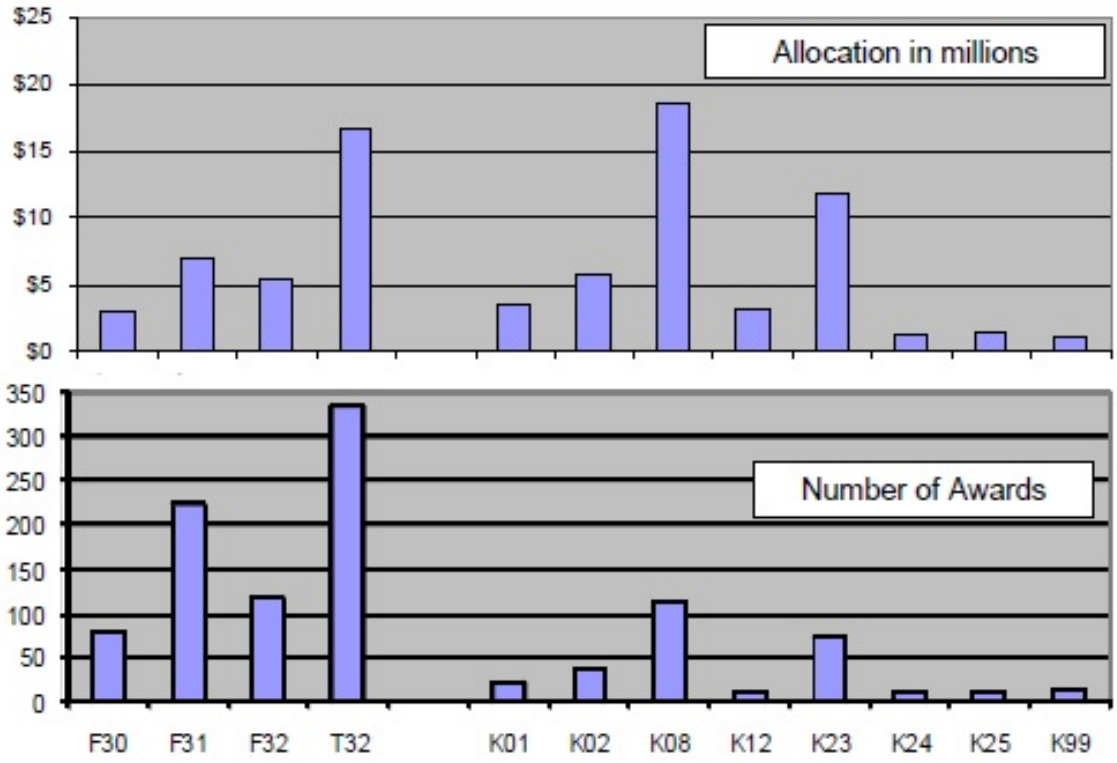



**Figure 5. NINDS Funding and Number of Awards for Different Training Mechanisms (FY07)**

The Panel strongly supported training programs, which provide not only a foundation for the continued academic enterprise but also a national resource for the development of biomedical enterprise. Such a resource is fundamental in positioning the U.S. at the forefront of the biotechnology and pharmaceutical industries.

**5.1 In general the Advisory Panel thinks that the training program in basic and disease-related basic research is a good investment and represents a critical component of the portfolio that should be expanded as resources allow.**

## A. T32 Training programs

NINDS supports two different T32 programs: one program is sponsored solely by the Institute (henceforth referred to as NINDS T32) and supports advanced (dissertation stage) pre-doctoral and/or post-doctoral PhD or MD trainees; a second program, the Jointly Sponsored Institutional Pre-doctoral Training Program in the Neurosciences (or Joint T32), is sponsored by multiple neuroscience Institutes (NIA, NIAAA, NICHD, NIDCD, NIDA, NEI, NIGMS, NIMH, NINDS, NINR and ODS) and supports only early stage pre-doctoral candidates.

<u>NINDS T32 Program</u>

Applicants to the NINDS T32 program may request any ratio of slots for predoctoral or postdoctoral trainees and proposals are required to have a central focus or a theme. The theme may be as broad or as narrow as deemed by the applicant institution, but should be more focused than, for example, "training in neuroscience." Funds are used to support novel and/or

expanded training experiences and activities, rather than simply supporting trainees in a department. Awards are typically made for a maximum of 4 trainees per year, although NINDS has recently implemented a policy that allows exceptions in rare and justifiable circumstances for up to 8 slots.

A breakdown of all NINDS T32 active grants by focus and by type of trainee (MD, PhD, or both) is provided in **Appendix V-D**. In FY07 the budget for the NINDS T32 program was $14,077,069, which supported a total of 68 programs and 289 trainees. Of these, 212 were postdoctoral and 77 were predoctoral trainees. A considerable number of the awards (29/68) supported some amount of MD or MD/PhD predoctoral or postdoctoral trainees. Below, we provide a comparison of the number of positions supported by the NINDS T32 and T32 Programs at other ICs.

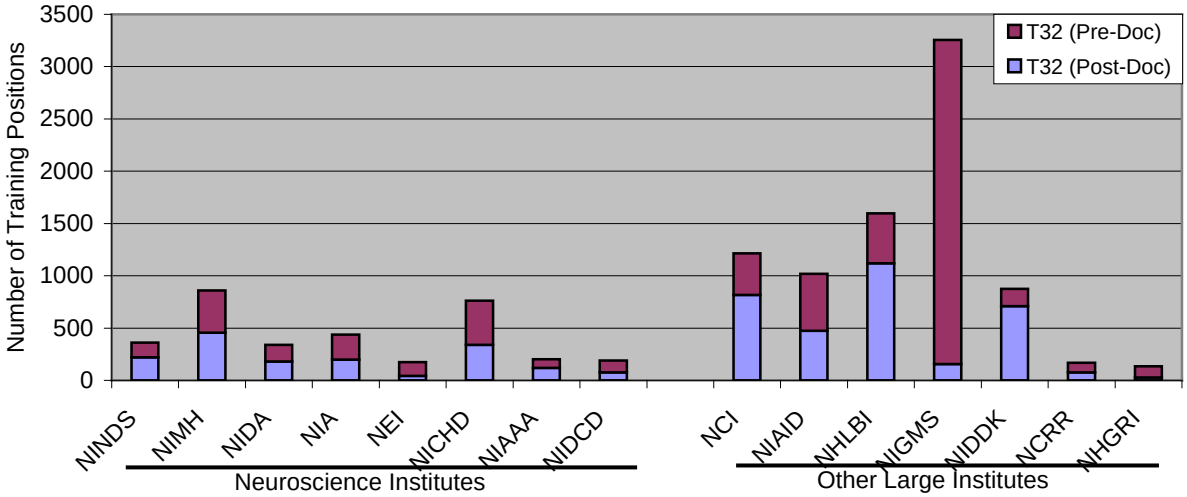



**Figure 6. Positions Allotted to T32 Institutional Training Awards**

Joint T32 Program

The Jointly Sponsored Institutional Predoctoral Training Program in the Neurosciences (Joint T32) aims to encourage broad and fundamental training in the neurosciences by offering institutions a single comprehensive training grant for the support of early-stage predoctoral trainees in the neurosciences. The awards provide support for trainees in their early years of graduate training while they remain relatively uncommitted as to specific research programs and typically before full-time thesis research begins. The Joint T32 Program encourages a curriculum that spans the breadth of the neurosciences in terms of the level of analysis (genes to molecules to cells to integrated, functional systems and behavior), approaches (including translational research), and the neuroscience of disease and disorders.

Participating NIH Institutes contribute according to the proportion of neuroscience research they support and the money is pooled. In FY07, the Joint T32 Program supported 30 T32 programs at different institutions with a total of 192 predoctoral students. The total budget for the program was $7,684,853 with NINDS contributing $2,688,312 or 35% of the funds. The historical contribution of each participating IC in terms of number of slots supported is provided in **Appendix V-E**.

Panel's Findings

The Panel recognized that T32 programs provide an important contribution to the pipeline of future NINDS researchers because they create an educational and training environment which other students can benefit from. This strength of the T32 program does not, however, carry over to the training of postdoctoral researchers, who have completed course-work requirements and who, for the most part, have already narrowed their research interests to a specific topic. Given their personalized goals, training for postdocs should be focused on developing independent thinking and research design and is best achieved through individual F32 fellowship support.

**5.2 The Panel is particularly supportive of T32 training programs for predoctoral students because, compared to individual predoctoral fellowship awards, they provide a broader programmatic and educational environment**.

**5.3 The Advisory Panel recommends that NINDS training support might be more effectively invested in later-stage predoctoral rather than postdoctoral T32 programs.**

Due to the already strong support of early-stage predoctoral trainees through the Joint T32 Program, the Panel offers the following recommendation:

**5.4 NINDS currently provides sufficient support for early stage predoctoral T32 training through the Jointly-Sponsored Neuroscience Training Program. Therefore, it is not in the best interest of NINDS to significantly expand its current investment in broad early stage (1$^{st}$-year) training programs.**

While early-stage support for predoctoral students in general neuroscience is crucial, students at such an early stage may turn their research focus away from topics of interest to the mission of NINDS. Thus the Panel deems that a separate Institutional Training Program managed solely by NINDS (the NINDS T32) serves the Institute well. However, the Panel is concerned with the lack of NINDS support for students during the stage of predoctoral training when trainees usually decide on a research laboratory and thesis project. Providing training on topics closer to the goals of NINDS, including disease-related research, to students at this training period can be especially fruitful. Thus, the Panel offers the following recommendations:

**5.5 The Panel thought that predoctoral students in their 2nd or 3rd year, and thus beginning specific thesis research, are relatively underserved by current NINDS training programs. The development of small (3-6 students) T32 training grants by NINDS for students at this stage would provide a synergistic and supportive academic environment larger than that provided by a single laboratory.**

**5.6 The Panel supports focused training programs that are oriented toward the goals of NINDS including cohesive environments that foster research in basic and translation research.**

One topic of particular concern to Panel members who had been principal investigators on training grants was the administrative burden that the NIH T32 application and review process places on academic institutions. A typical T32 application is on the order of 200-400 pages, calls for the creation of 9 information tables, and requires the collection of historical information

from multiple students going back many years. Many times, T32 proposals have to go through several rounds of revision in order to get funded and reviewers' comments were judged often to be arbitrary or capricious. All this effort is typically performed to generate support for only 4-5 trainees a year.

The NINDS Training Office informed the Advisory Panel that in response to similar concerns from the broader academic community it has implemented a number of changes to the management and review of the NINDS T32 program. For example, whereas T32 applications had previously been reviewed in conjunction with K awards, NINDS had recently established a study section solely devoted to T32s. This new review panel included reviewers who had been principal investigators on previous T32 awards and therefore had specific expertise in evaluating these applications. Reviewers are now asked to put more emphasis on the outcomes of training programs (i.e. whether trainees go on to continue research) as opposed to the characteristics of their incoming students. It was expected that this would greatly improve the review process and that a higher number of quality institutional training programs would be awarded without requiring resubmission. In addition, NINDS had changed its policies so that programs with unique circumstances could now request up to a maximum of 8 trainee spots, increasing the flexibility of the mechanism to be tailored to the specific needs of an institution. With regard to the T32 application forms, the Director of the NINDS Training Office informed the Panel that because this is an NIH-wide document it would be difficult to modify. In addition, T32 reviewers often appreciate detailed information in order to distinguish among programs.

**5.7 We think the T32 application process is unnecessarily cumbersome and would be improved by a more streamlined application. The Panel realizes that recent policy modifications have been put into place and that some procedures are NIH-wide, but we urge close monitoring to optimize the process.**

## C. Individual Fellowship and Career Development Programs

Individual Fellowships

NINDS has always had strong investment in the Individual National Research Service Award Fellowship programs, providing support for individual predoctoral (F31), postdoctoral (F32), or MD/PhD (F30) trainees. NINDS is one of 7 NIH institutes that support the F31 mechanism for the general population (nearly all Institutes support F31 fellowships for diversity). In 2007, NINDS supported 79 MD/PhDs ($2.9 million), 224 PhD candidates ($7 million), and 118 postdocs ($5.5 million), exceeding the numbers of a majority of neuroscience ICs.

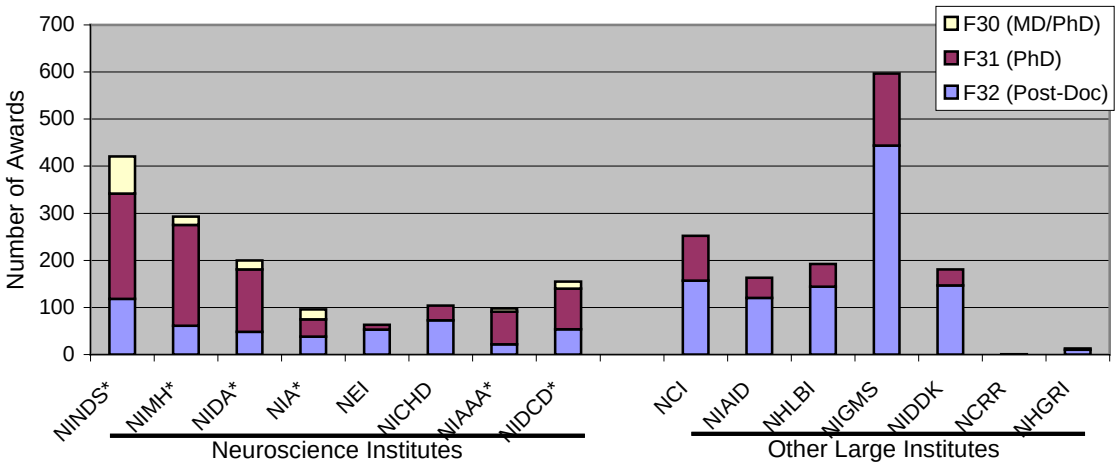



**Figure 7. Number of Individual Fellowships by Institute (FY07) –** Asterisks indicate Institutes that offer F30 (MD/PhD) and F31 (Pre-Doctoral) Fellowships to the general trainee population. The rest of NIH does not offer MD/PhD fellowships, and only offers F31 fellowships for underrepresented minorities and individuals with disabilities.

The Panel found the F31 and F32 mechanisms to be valuable to NINDS for a variety of reasons. For predoctoral students, the existence of the F31 mechanism allows for the identification of outstanding trainees, permits labs and departments to admit and train more students than it otherwise would, and helps labs and departments buffer the ebb and flow of R01 support. For both PhD students and postdocs, the Panel agreed that the act of writing an NIH application is an excellent training exercise and individual fellowships provide rewards to those students who excel. This last contribution is of crucial importance for the career development of postdoctoral candidates on F32s.T32 support cannot supplement the experience of writing a fellowship proposal.

The Panel was interested in studies evaluating the F32 program. Although NIH has conducted evaluations on several of its training programs, a high-quality evaluation is difficult to accomplish because it is hard to track the professional outcome of students or to develop an appropriate control group to compare them to.

In light of these findings the Advisory Panel recommends the following:

**5.8 The F32 program was considered to be successful, although accurate outcome measures of success are needed.**

<u>Career Development Awards (or “K” series)</u>

NINDS provides support for different mechanisms that aim to enable scientists with diverse professional and academic backgrounds to enhance their careers in biomedical research and to augment the workforce that is researching problems of relevance to the mission of NINDS. To this end, NINDS uses a number of career development mechanisms. Most mechanisms are geared towards increasing the number of physician-scientists addressing neurological research questions (K02, K08, K23, and K24), but a few are for individuals with a research doctorate (K01, K25, and K99/R00). Descriptions of each mechanism are listed in **Appendix V-A**.

In 2007, approximately $47 million or 59% of the NINDS training budget was devoted to support the career development of 291 scientists. K awards are a big portion of the NINDS training expenses because most of these awards cover a portion of the investigator's salary and may also cover mentoring expenses. A comparison of the budget and number of trainees supported by all NINDS training mechanism can be seen in **Figure 5**.

The K08 and K23 are the major NINDS career awards. The K08 Mentored Clinical Scientist Research Career Development Award program is designed to provide "protected time" for clinically trained individuals to participate in an intensive, supervised training program in biomedical research, including translational research, related to neurological disorders. The K23 Mentored Patient-Oriented Research Career Development Award was created to support the career development of clinically trained professionals (MD or equivalent) who have made a commitment to focus their research endeavors on patient-oriented research. For the purposes of this award, patient-oriented research is defined as research conducted with human subjects (or on material of human origin such as tissues, specimens, and cognitive phenomena) for which an investigator directly interacts with human subjects.

While the Panel saw a need to train clinical scientists, all members agreed that PhDs may be equally qualified to do disease-related research. It would be a good use of NINDS budget to extend the eligibility for career development programs focused on disease-related research to PhDs as well as MDs and the Panel saw no need to expand the K awards for MDs. The small K25 program, which provides support for young PhDs (within 5 years of degree) in the quantitative sciences (physics, engineering, chemistry, etc.) to research neuroscience questions, was judged to be a good investment by the Panel.

**5.9 The K award programs for clinicians are well represented in the portfolio. We think that PhDs are an underutilized resource for disease-related research, thus NINDS should consider developing this type of training program for PhDs.**

In terms of the K99/R00, the Panel regarded this as an important program that was responsive to the need to facilitate timely transition from a mentored postdoctoral position to a stable independent research position. In 2007 (the first year of this program), NINDS funded 13 awards, totaling $857,792 for the initial mentored phase. So far all of the 2007 K99 awardees except one have been offered faculty positions. In light of these very preliminary data, the Panel encouraged NINDS to continue its support and to monitor its effectiveness. The investment in this program is still quite small and should be expanded if outcome evaluations deem it to be successful.

**5.10 The K99/R00 mechanism was widely acknowledged to be working well and should be maintained. If outcomes continue to show this program is effective the Panel recommends its expansion**.

Outcomes Assessments

In discussions with the NINDS Training Office, it became apparent to the Advisory Panel, that a number of training programs at NINDS had not been fully evaluated for effectiveness in achieving the training programs goals. For example, while the NINDS Advisory Council has repeatedly stressed the need to support MD/PhDs through the F30 program, the value of this program has never been assessed in terms of outcomes (e.g., what portion of the fellows stays in research). Likewise, a full evaluation of the success of career development awards is needed. A recent NINDS evaluation shared with the Panel determined that approximately 68% of K02, 30% of K08, and 15% of K23 awardees went on to obtain an R01. The NINDS Training

Office is hoping to conduct more thorough evaluations of the career paths of these awardees and to determine whether there may be other important contributions to research that these awards may be serving.

The Advisory Panel was concerned that a big proportion of K trainees or MD/PhDs do not continue in research careers. The panel encouraged the collection of career outcomes data for these as well as for traditional PhD training support. These data are of absolute need in order to justify the expense of specific training programs, particularly the F30 and K awards. However, Panel members noted that outcomes should be carefully selected and weighed and "success" should be determined carefully, taking into account the big picture of research and practicalities specific to different types of investigators or research fields. For example, Panel members noted that acquiring an R01 might not be a suitable outcome for K23 awardees who are hoping to become clinical researchers, while it might be a reasonable expectation for an F32 fellow. Clinical research is often done by teams of researchers, all of which who play a major part in the study, but only one or two of which will be "principal investigator." Combinatorial metrics of accomplishments such as number of publications and/or their impact, as well as funding history, might more accurately reflect effective training than simple dependence on subsequent R01 successes. Thus, in addition to recommendation 5.8 on the need for accurate outcome measures for F32s, the Panel recommends that:

**5.11 Outcome measures must be developed and applied to be in line with each type of individual fellowship training program to assess their effectiveness.**

# APPENDICES:

# I. NINDS Support for Basic Research

## A. Neuroscience Research at NIH

Nearly all NIH applications are received by the NIH Center for Scientific Review (CSR), which is responsible not only for their distribution to study sections for review, but also to the various NIH Institutes for funding. To accomplish this, the CSR Division of Receipt and Referral uses multiple criteria, including the scientific aims of each application, requests made by investigators, requests made by institutes/centers, issuance of program announcements, and the history of the training and career support of the investigators. For guidance in assessing the scientific relevance of applications to the missions of the various NIH Institutes, CSR uses a set of internal working documents, "*Referral Guidelines for Funding Components of the Public Health Service*," which were last revised in 2004 in collaboration with the Institutes. These include specific referral guidelines for each Institute, along with policies regarding areas of overlap (see Appendix 3 for the NINDS Referral Guidelines document). It is important to note that these are only general guidelines, since each Institute functions independently in assessing and updating its funding priorities.

As seen in the following figure, many institutes at NIH contribute to funding neuroscience research. NINDS is the largest contributor, funding nearly one-third of the $4.8 billion coded as neuroscience research at the NIH.

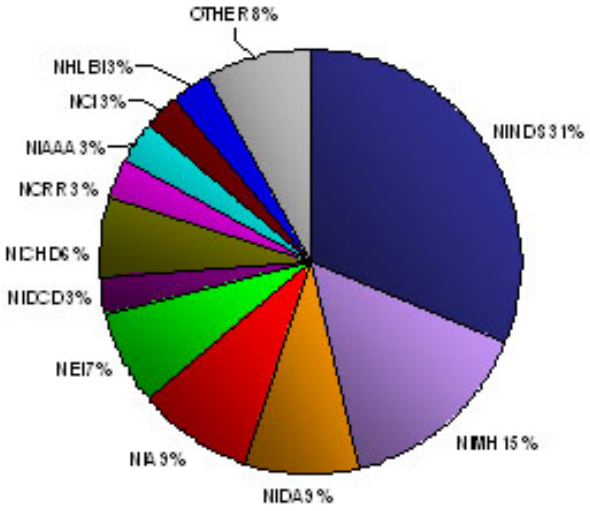



**Figure 8. Neuroscience funding by different NIH Institutes**

## B. Current Activities that Inform the Public about the Importance of Basic Neuroscience Research

**National Institutes of Health (NIH)**
News highlights from various NIH Institutes/Centers (ICs) and general NIH news are provided at http://www.nih.gov/news/. Every NIH IC provides information for lay audiences via their individual institute web pages.

***National Institute of Neurological Disorders and Stroke (NINDS)***

- The NINDS Office of Communications and Public Liaison (OCPL) writes news stories targeted to the public, has an archive of NINDS congressional testimonies, and notes from NINDS workshops and forums on the News and Events page: http://www.ninds.nih.gov/news_and_events/press_releases/index.htm. Most news items cover studies related to therapeutic development. However, toward the more basic end, recent stories have covered the construction of a gene expression profile for mature astrocytes, the crystallization of the beta-adrenergic receptor, and the generation of "Brainbow" mice whose neurons express unique combinations of fluorescent proteins that make them distinguishable by color.
- NINDS "Brain Basics" series. Targeted toward a high school level.
  - o "The Life and Death of a Neuron" www.ninds.nih.gov/disorders/brain_basics/ninds_neuron.htm Describes the cell biology and life history of neurons, including birth, migration, differentiation and death. Also explains how basic research on how birds learn to sing contributed to the discovery of neurogenesis in the adult brain.
  - o "Know Your Brain" www.ninds.nih.gov/disorders/brain_basics/know_your_brain.htm Describes the organization of the human brain, and points to the importance of basic neuroscience.
  - o "Understanding Sleep" www.ninds.nih.gov/disorders/brain_basics/understanding_sleep.htm Describes stages of sleep, circadian rhythms, and why we need sleep.
- NIH/NINDS Curriculum Supplement: "The Brain: Our Sense of Self" (Grades 7-8) (http://science.education.nih.gov/customers.nsf/MSSelf?OpenForm). Produced in collaboration with the NIH Office of Science Education (OSE), this teaching aid contains five structured lessons about: how the brain shapes individual identity, localization of brain functions, spinal reflexes, case studies in brain injury, and learning and memory.

***NIH Office of Science Education (OSE)***

- "How Your Brain Understands What Your Ear Hears" (Grades 7-8) (http://science.education.nih.gov/Customers.nsf/MSHearing?OpenForm). Explores the biology of hearing.
- "Sleep, Sleep Disorders and Biological Rhythms" (Grades 9-12) (http://science.education.nih.gov/Customers.nsf/HSSleep?OpenForm)
- "The Brain: Understanding Neurobiology Through the Study of Addiction" (Grades 9-12) (http://science.education.nih.gov/Customers.nsf/HSBrain?OpenForm)
- "Doing Science: The Process of Scientific Inquiry" (Grades 7-8) (http://science.education.nih.gov/customers.nsf/MSInquiry.htm) Teaches kids how to ask scientific questions, and emphasizes that except for ethical issues, there is almost no scientific question not worth asking.

***National Center for Research Resources (NCRR)***

- The Science Education Partnership Award (SEPA) program (http://www.ncrrsepa.org/) funds grants for innovative educational programs. Such projects create partnerships among biomedical researchers and K-12 educators, museums and science centers, and educational/outreach organizations. Several SEPA projects have a neuroscience focus. For example:
  - o BrainU (http://www.brainu.org/index.htm). From the University of Minnesota and Science Museum of Minnesota. Offers professional development workshops for science teachers, plus brain models, lesson plans and other media to use in the classroom.

- o Amazing Feats of Aging (http://www.omsi.edu/visit/life/aging/index.cfm). From Oregon Museum of Science and Industry. A "carnival-like," hands-on exhibit that explores the aging process, including a look at aging in animals.
- o BrainLink (http://www.ccitonline.org/ceo/content.cfm?content_id=80). From Baylor College of Medicine. Teaching modules on brain chemistry, sensory and motor systems, and a comparison of the human brain to animal brains.
- o Brain Research in Education (http://www.extension.washington.edu/ext/certificates/bre/bre_gen.asp). From the University of Washington. Offers professional development courses for K-12 science educators, including a course about "the processes of brain research."
- o The MIND Project (http://www.mind.ilstu.edu/community/K12/workshops/08aug.html). From Illinois State University. Includes virtual labs that allow students to play the role of neuroscientists studying animal models of Parkinson's disease and drug addiction.

***National Institute on Drug Abuse (NIDA)***

- The Science Education Drug Abuse Partnership Awards (SEDAPA) program (http://www.nida.nih.gov/SEDAPA/index.html) funds the development and evaluation of educational programs about the neurobiology of drug addiction.
- Attitude Boost: A Multimedia Curriculum to Improve Attitudes Toward Science. Under development with an SBIR grant to KDH Research and Communications, Inc. Aims to improve students' attitudes toward science, their scientific literacy and their academic performance on science projects, particularly those related to drug abuse.
- Brain Power! A set of materials for grades K-5 and middle school that explores scientific processes and how to use them to study the nervous system and the effects of drugs on the nervous system.

***National Institute of General Medical Sciences***

- Curiosity Creates Cures (http://publications.nigms.nih.gov/curiosity) is a free publication (downloadable online or mailed by request) that explicitly conveys the role of pure basic research in leading to health advances. The high rate of return on investment in basic research is highlighted, and several examples of basic research findings that led to important clinical advances are given. In addition, the value of model organisms, scientific collaboration, and adequate funding are explained.
- Findings (http://publications.nigms.nih.gov/findings/) is a free monthly publication (online or mail subscription) that connects advances in scientific research to improvements in health care. The newsletter archive is searchable by topics, such as behavior, diseases, sleep, pain, circadian rhythms, and pharmacology. Stories about scientists and their research are told in lay-friendly language. Videos, podcasts, slide kits, and other classroom materials are also provided.

**Society for Neuroscience (SfN)**

The Society for Neuroscience (SfN) is a non-profit advocacy organization for neuroscientists and physicians who study the brain and nervous system. Aside from its scholarly scientific journal and annual meeting, the SfN works to educate the public about the findings, applications, and potential of neuroscience research. Their website provides links to lay neuroscience publications and educational resources. SfN has an education and communication committee charged with sharing the importance of neuroscience with the public. As part of its charter, this committee facilitates communication between SfN and media, K-12 teachers, education leaders, advocacy groups, elected officials, and the public. The committee maintains strong relationships with education organizations such as the National Science Teachers Association (NSTA), National Association of Biology Teachers (NABT), and the Dana Alliance for Brain Initiatives (DABI)

- Brain Research Success Stories (http://www.sfn.org/index.cfm?pagename=brainResearchSuccessStories) contain articles designed to tell elected officials and the public about the recent successes and future potential of neuroscience. They explain how neurological and psychiatric disorders can be overcome only through continued increases in federal biomedical funding.

- Translational Neuroscience Accomplishments (http://www.sfn.org/index.cfm?pagename=gpa_TranslationalAccomplishments) explains the impact of animal research on the understanding and treatment of human brain disorders.
- "Research and Discoveries" (http://www.sfn.org/index.cfm?pagename=publications_rd&section=publications) A new publication recently launched to underscore the importance of how curiosity-driven basic research leads to advances in human health.
- The Neuroscientist-Teacher Partner Program (http://www.sfn.org/index.cfm?pagename=neuroscientistTeacherPartners) partners K-12 educators with Society members who have volunteered their time. An interactive map allows users to see names and locations of participating neuroscientists.
- Brain Briefings (http://www.sfn.org/index.cfm?pagename=brainBriefings_main) is a series of two-page monthly free newsletters explaining how basic neuroscience discoveries lead to clinical applications. According to the SfN Public Education and Communication Committee Annual Report for 2007, it is the most visited site on the SfN Web site after the annual meeting and membership directory.

**Dana Foundation**

The Dana Foundation is a private philanthropy with principal interests in brain science, immunology, and arts education. The Dana Press publishes books, news, and opinions on health and popular science for the general reader. The Dana Alliance for Brain Initiatives (DABI) is a nonprofit organization of 260 eminent neuroscientists, including 10 Nobel Laureates. It is committed to advancing public awareness about the progress and benefits of brain research and to disseminating information on the brain in an understandable and accessible fashion.

- Brain Awareness Week (BAW) (http://brainweek.dana.org/) The Dana Alliance created Brain Awareness Week in 1996 to focus worldwide attention on the benefits and progress of brain research. Held in March, Brain Awareness Week unites the efforts of universities, hospitals, patient advocacy groups, government agencies, service organizations, professional groups, and K-12 schools around the world in an annual celebration of the brain. The Brain Awareness Week campaign includes more than 2,100 partners in 75 countries and benefits from the participation of key stakeholders such as the Society for Neuroscience and Pilot International, whose broad reach and chapter base have helped expand this grassroots effort into a truly global initiative. NINDS, along with several other NIH institutes, participates in BAW every year.
- BrainWeb (http://www.dana.org/resources/brainweb/default.aspx) provides information and links to validated sites about brain diseases and disorders. These include outside resources reviewed by scientific advisors as well as articles in Dana publications. Sites listed in BrainWeb detail more than 25 common brain diseases and disorders, and include some of the Internet's best general neuroscience and health resources. They offer descriptions of conditions, FAQs, background for talking with physicians, treatment options, support information for families and caregivers, organization contacts, and sources for more information. BrainWeb and its links are suitable for lay readers, including students and educators, as well as people with brain disorders, their families, and caregivers.
- BrainWork (http://www.dana.org/news/brainwork/) is a bimonthly publication with articles on the latest neuroscience research.
- Cerebrum (http://www.dana.org/news/cerebrum/) is an online journal of opinion related to neuroscience research, and can be requested as an e-mail alert.
- Brain in the News (http://www.dana.org/news/braininthenews/) includes recommended reading selected by Dana editors, including articles and Web sites from around the world highlighting the latest discoveries about the brain. The online version is updated weekly, and a free monthly print edition is sent to more than 30,000 subscribers.
- Dana Gray Matters (http://dana.org/podcasts.aspx?podcast=%20Gray%20Matters) is an "award-winning" radio series on Public Radio International focusing on neuroscience and neurology topics, targeted to adults. It can be downloaded for free on the Dana website as a podcast. Dana Alliance members serve as advisors to Gray Matters programming and are interviewed during the programs.

**National Science Foundation**
The NSF is a federal agency whose mission includes support for all fields of fundamental science and engineering, and is charged "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes" (NSF Act of 1950). The NSF clearly has education (from pre-K to graduate school and beyond) as part of their mandate, and makes an effort to encourage all grantees to participate in educational activities.

- The NSF asks all grant applicants, "What are the broader impacts of the proposed activity?" The Broader Impacts merit review criterion (BIC) may be met with activities that promote teaching, training and learning, or benefit to society (see http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf). It has been in effect for more than ten years.
- NSF GK-12 Fellowships (http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5472&org=DGE) provide funding for NSF-supported graduate students to provide educational activities in the K-12 arena. Although few are focused on neuroscience topics, many of the projects promote learning through investigation and experimentation.

**Howard Hughes Medical Institute**
HHMI is a non-profit medical research organization that ranks as one of the nation's largest philanthropies, and plays a powerful role in advancing biomedical research and science education in the U.S.

- Science Education Alliance (http://www.hhmi.org/grants/sea/) Announced in October 2007, this program will offer an energetic and dynamic environment headquartered at HHMI's Janelia Farm Research Campus and staffed by trained scientists dedicated to education. Among other activities, workshops, short courses, institutes, and symposia will be held to train educators in the newest innovations in science education.
- Precollege Science Education Program (http://www.hhmi.org/grants/office/precollege/) These are 5-year grants (up to $150,000/year) offered to invited biomedical research institutions every 5 years. The purpose is to improve K-12 science education by encouraging hands-on activities and teacher development. There is currently one active program having some focus on neuroscience, and this is a summer program for gifted high school students at the University of Cincinnati.
- HHMI's Online Resource Center for scientists, educators, parents, and students (http://www.hhmi.org/resources/) Provides links to resources developed by HHMI, HHMI grantees, and others. These resources include research summaries of HHMI scientists, opportunities for research training and professional development, online learning, and exciting interactive experiences for learning about science. One of these resources is a neuroscience lecture series for the public (http://www.hhmi.org/biointeractive/neuroscience/lectures.html).

**American Association for the Advancement of Science (AAAS)**
In addition to publishing *Science* and other science-related publications, hosting scientific conferences and meetings, and helping scientists advance their careers, AAAS undertakes numerous programs and activities that promote science to the public and monitor issues which affect the scientific community.

- Project 2061 (http://www.project2061.org/) A long-term AAAS initiative to advance literacy in Science, Mathematics, and Technology. They conduct research and develop educational tools and resources for educators, researchers, parents and families, and community leaders to improve the nation's education system. This is not neuroscience-specific, but focuses on promoting understanding of the ideas and skills underlying science in general.
- Science Update (http://www.scienceupdate.com/index.php) A daily 60-second feature covering the latest discoveries in science, technology and medicine. They also answer listener's questions through an online form or toll-free answer line. The show is available to commercial radio stations nationwide, and is downloadable as a podcast.

**Federation of American Societies for Experimental Biology (FASEB)**
FASEB consists of 21 member societies, and its mission is to advance biological science through collaborative advocacy for research policies that promote scientific progress and education and lead to improvements in human health.

- FASEB has a general statement on their Web site regarding Benefits of Biomedical Research (http://opa.faseb.org/pages/PolicyIssues/benefitsbiomedical.htm), with links to sources of information on recent accomplishments.
- They also publish Breakthroughs in Bioscience (http://opa.faseb.org/pages/Publications/breakthroughs.htm), a series of illustrated essays that explain recent breakthroughs in biomedical research and how they are important to society, with hard copies available upon request. Only a small proportion of these are Neuroscience-related.

**The Science Coalition**
(http://www.sciencecoalition.org/index.cfm) A non-profit coalition of 45 U.S. research universities that advocates for federal support of basic science. Publications include the report, "Within Our Grasp or Slipping Away? Assuring a New Era of Scientific and Medical Progress." (http://www.sciencecoalition.org/sites/sciencecoalition.com/images/File/nih_funding.pdf) The book's premise is that maintaining the nation's global leadership in biomedical progress and delivering advances in health care requires "a strong and vibrant program of basic research." Part of the book describes how basic neuroscience research has led to new strategies for treating spinal cord injuries and motor neuron diseases.

**Research!America**
(http://www.researchamerica.org/) A non-profit organization "committed to making research to improve health a higher national priority." They write "issue reports" that provide facts about different neurological diseases and discuss the economic impact of therapeutic advances (http://www.researchamerica.org/issue_briefs). A March 2008 ad campaign highlights how basic research in physics and engineering led to technologies like MRI and lasers (http://www.researchamerica.org/uploads/ad.basicscience.pdf). Perhaps something similar could be done for basic neuroscience research? They also collect polling data on public perception of research, including how much the public values basic research. For example, in a 2006 survey, when asked about the statement, “Even if it brings no immediate benefits, basic research which advances the frontiers of knowledge is necessary and should be supported by the federal government,” 69% of survey participants indicated they agreed strongly/somewhat, compared to 27% who disagreed strongly/somewhat. (Your Candidates—Your Health Survey, 2006, Charlton Research Company for Research!America. http://www.researchamerica.org/uploads/pollreport2006yourcandidates.pdf.)

# II. Balance of the NINDS Basic Research Portfolio

## A. NINDS Extramural Research Portfolio Organization

**NINDS Clusters Assigned to Scientific/Disease Research Areas**
Most grants received by NINDS are assigned to one of six "clusters," which consist of teams of Program Directors and associated staff, and are organized around scientific/disease areas. Within each of these six clusters, individual Program Directors are charged with expertise and oversight in specific research topics, and are expected to manage portfolios in collaboration or consultation with other cluster members. Each of the clusters integrates both fundamental neuroscience and disease-related projects, including basic research and therapy development. The major research portfolios maintained by each cluster are listed below. More detailed information regarding scientific areas covered by the clusters and individual Program Directors can be found on the NINDS website:
(http://www.ninds.nih.gov/funding/pd_interests.pdf).
For information on the backgrounds and expertise of specific Program Directors, see:
http://www.ninds.nih.gov/find_people/ninds/contact_people.htm.

*Channels, Synapses, and Neural Circuits*
Ion channel and transporter biophysics and function - *Dr. Silberberg, Dr. Stewart*
Synapse biology and synaptic transmission - *Dr. Talley*
Intracellular signaling mechanisms - *Dr. Stewart, Dr. Talley*
Epilepsy - basic and clinical studies - *Dr. Margaret Jacobs, Dr. Stewart*
Molecular genetics and antibody resources - *Dr. Stewart, Dr. Talley*

*Neural Environment*
Cerebrovascular biology and vascular regulation - *Dr. Tom Jacobs, Dr. Golanov*
Stroke mechanisms - *Dr. Jacobs, Dr. Golanov*
Cell death and neuroprotection - *Dr. Golanov*
Glial biology - *Dr. Fountain, Dr. Jacobs, Dr. Utz*
Brain tumors and associated neurological disorders - *Dr. Fountain*
Neuro-AIDS, neurovirology, infectious diseases - *Dr. Wong*
Multiple Sclerosis - *Dr. Utz*
Myelin function and repair - *Dr. Utz*
Neuroimmunology - *Dr. Utz*

*Neurodegeneration*
Parkinson's Disease - *Dr. DiEuliis, Dr. Refolo, Dr. Sieber, Dr. Sutherland*
Alzheimer's Disease - *Dr. Refolo, Dr. DiEuliis*
Adult onset trinucleotide repeat disorders and ataxias- *Dr. Sutherland*
ALS and other adult onset motor neuron disease- *Dr. Refolo*
Stem cells, clinical and applied research- Dr. Sutherland
Other adult onset neurodegenerative disorders (MSA, Pick's disease, Hallevorden-Spatz, tauopathies, synucleinopathies, amyloidopathies) - *Dr. DiEuliis, Dr. Refolo, Dr. Sieber, Dr. Sutherland*
Animal model resources - *Dr. DiEuliis, Dr. Refolo, Dr. Sutherland*

*Neurogenetics*
Whole genome association studies, genotype-phenotype analysis - *Dr. Gwinn, Dr. Tagle*
Genomics, gene regulation, proteomics, metabolomics - *Dr. Tagle*
Gene therapy and gene delivery - *Dr. Tagle*
Lysosomal storage and DNA repair disorders, mitochondrial and other rare diseases - *Dr. Tagle*
Muscular dystrophies, myopathies, neuropathies - *Dr. John Porter*
Dystonia, ataxias - *Dr. Gwinn, Dr. Tagle*
Neurodevelopment - *Dr. Riddle, Dr. Mamounas*
Autism spectrum disorders, mental retardation syndromes - *Dr. Riddle, Dr. Mamounas*

Molecular genetics and antibody resources - *Dr. Riddle, Dr. Mamounas*

*Repair and Plasticity*
Traumatic brain injury - *Dr. Hicks*
Spinal cord injury - *Dr. Kleitman*
Peripheral nerve regeneration/repair - *Dr. Kleitman*
Stem cell biology and therapy development - *Dr. Owens*
Endogenous neurogenesis - *Dr. Owens*
Brain-machine interface, neural prostheses - *Dr. Pancrazio*
Bioengineering, biomaterials, nanotechnology - *Dr. Pancrazio*

*Systems and Cognitive Neuroscience*
Sensorimotor systems and circuits - *Dr. Chen*
Cognitive and behavioral neuroscience - *Dr. Babcock*
Homeostatic and neuroendocrine systems - *Dr. Mitler*
Sleep and circadian biology, sleep disorders - *Dr. Mitler*
Metabolic regulation and obesity - *Dr. Mitler*
Pain pathways and mechanisms, diagnostic/therapy development - *Dr. Linda Porter*

**Other NINDS Components Contributing to Extramural Research Portfolio Management**
Basic, clinical, and translational research efforts are integrated across the Institute, with extensive collaboration between the six Program clusters that cover specific scientific and disease areas and other components of NINDS.

*Clinical Trials*
Most NINDS-funded clinical research is managed by a separate Clinical Trials Cluster, but Program Directors from every cluster are involved in management of clinical research, depending on need and expertise.

*Technology Development Branch*
The Technology Development Branch manages some of the major translational and research infrastructure efforts at NINDS. These efforts are often in close collaboration and/or consultation with Program Directors from the various scientific and disease areas.

*Minority Health*
The Office of Minority Health and Research is responsible for research focused on reducing health disparities, and increasing disease prevention in populations that are at increased risk for neurological disease. The Office also manages research training programs to promote diversity, and awards to minority-serving institutions.

*Training*
The Training Office is responsible for funding policy for training awards, and manages Institutional (T32) training grants. Program Directors from relevant scientific/disease areas are responsible for oversight of individual fellowships and career awards.

*Small Business Research Program*
Each NIH Institute is required by Congress to set-aside of 2.5% of their budgets for Small Business Innovation Research (SBIR) and 0.3% for Small Business Technology Transfer (STTR) programs. Within NINDS, individual small business grants are managed by Program Directors across the clusters, depending on the scientific area of focus.

## B. NINDS Grants Coding and New Categorization Efforts for Basic Research

**Existing Systems for Grants Coding**
NINDS maintains an annually-updated classification of its research portfolio that is used to provide Congress, disease advocacy organizations, and the general public with information on funding of different scientific/disease areas. This database contains 259 categories; 126 of these are reported on an NIH-wide basis (http://www.nih.gov/news/fundingresearchareas.htm). However, the categories in this coding

system are not intended to be comprehensive and are primarily focused on diseases. Therefore, although we used the NINDS Coding database in some instances (noted below), we sought alternatives to establish a framework for analyzing and assessing NINDS efforts in basic research.

**Grants Classification for the NINDS Strategic Planning Process**

*Goals*

1) A comprehensive, global view of the overall research portfolio that is readily accessible to members of our outside panel of experts.
2) Sufficient detail to assess how individual grants or groups of grants fit within the portfolio.
3) Categories generally recognizable to neuroscientists and comparable across NIH Institutes.
4) A framework that could be implemented in a short time-frame with limited resources.

*Utilization of Society for Neuroscience Annual Meeting Abstracts Databases*

For this effort we turned to text mining efforts utilizing abstract submissions to the Annual Meeting of the Society for Neuroscience (SfN). This dataset has a number of advantages, including that it provides a global view of neuroscience research allocations independent of funding sources, and that abstract authors self-categorize their research into pre-specified "Themes," "Subthemes," and "Topics," which are major determinants of meeting session assignments. Partha Mitra and colleagues (Cold Spring Harbor Labs) were kind enough to provide quantitative data regarding NIH funding sources attributed to each abstract.[1] Although author attribution of funding sources is only nominally mandatory, we believe they provide a reasonable representation of relative support by different NIH Institutes, because: a) relative funding levels in different individual categories are consistent with our knowledge of NIH Institute funding policies, and b) the overall distribution of NIH funding as reported by abstract authors very closely matches the relative funding levels reported by NIH Institutes (compare Figure 9 to Figure 8).

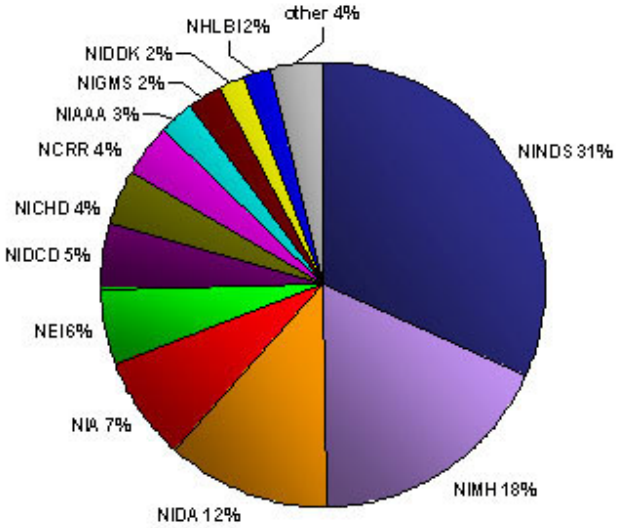



**Figure 9.** 2006 SfN Abstracts categorized by NIH funding source, based on author attribution at the time of submission.

We were also able to take advantage of graphics and informatics work by Gully Burns and colleagues (USC, UC Irvine, and Indiana), who have devised an interactive Google Maps-based representation of statistically determined topical relationships between SfN Abstracts (http://scimaps.org/maps/neurovis).[2]

[1] J.M. Lin, J.W. Bohland, P. Andrews, G. Burns, C.B. Allen, P.P. Mitra *An analysis of the abstracts presented at the annual meetings of the Society for Neuroscience from 2001 to 2006*. http://arxiv.org/abs/0710.2523.

[2] G. A. Burns et al. (2007) *A snapshot of neuroscience: unsupervised natural language processing of abstracts from the Society for Neuroscience 2006 annual meeting.* Society for Neuroscience Abstracts, http://www.sfn.org/am2007.

This map shows clusters of Abstracts that are textually related to one another, and it utilizes labeling and color coding based on SfN category assignments. Users can draw a bounding box around a subset of abstracts, whereupon a sidebar displays information regarding each abstract, including statistical data derived from text mining and topic analysis.[12] NINDS has contracted this team to compile a similar topical analysis and map of NIH funding for neuroscience research which we anticipate will allow users to assess topically related grants from multiple NIH Institutes rather than examination of NINDS grants in isolation.

**Distribution of NINDS and NIH Grants across SfN Themes and Subthemes**

To provide a global view of the distribution of NINDS research across the various areas of neuroscience, we categorized NINDS grants according to SfN Themes and Subthemes.[13] In order to focus on basic research, we restricted our analysis to Research Project and Program Project grants (see Figure 3). We thus omitted Cooperative Agreements, Contracts, and Small Business Grants, the majority of which are devoted to applied clinical and translational research (Research Resource projects were analyzed separately, see Section IV). In addition, we restricted our analysis to projects assigned to the six science/disease clusters (described above), since nearly all projects outside these clusters involve applied (i.e., therapy development or clinical trials) rather than basic research. It is worth noting that although our analysis excluded most clinical trials, it nevertheless included a substantial amount of human subjects research (~16% of the total projects analyzed), and a small amount of research (3.6%) coded by NINDS staff as translational (i.e., therapy development).

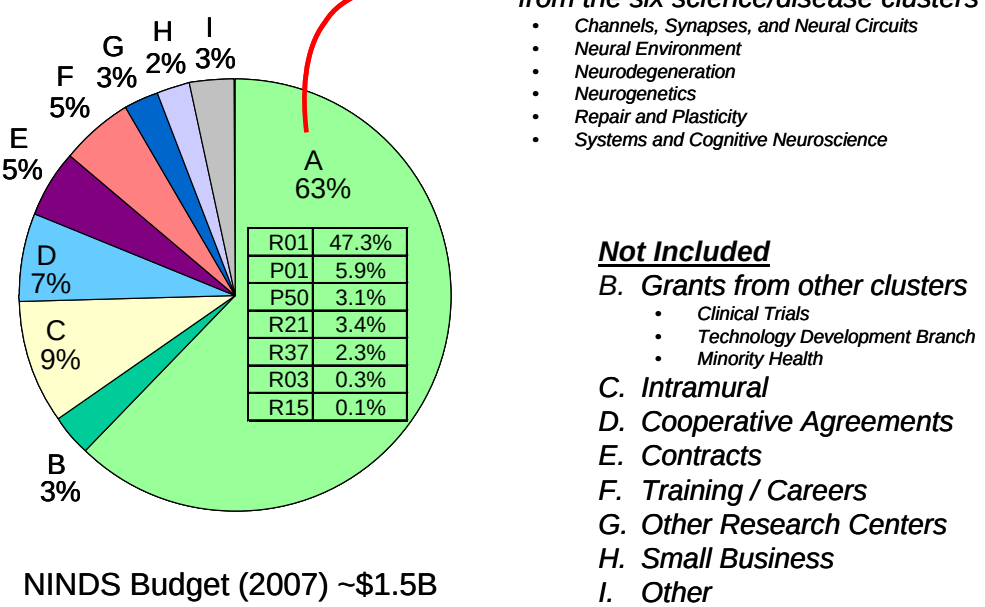



**Figure 10. Inclusion/exclusion of projects for analysis of NINDS research distribution.**

*Figures 11-18. Scientific distribution of NINDS grants according to SfN categories*

The figures on the following pages show histograms of NINDS funding for research in categories developed for abstracts submitted to the Society for Neuroscience. For each SfN Theme and Subtheme,

[12] Mark Steyvers and Tom Griffiths, *Probabilistic Topic Models* In T. Landauer, D McNamara, S. Dennis, and W. Kintsch (eds), *Latent Semantic Analysis: A Road to Meaning.* Laurence Erlbaum, weblink at: http://psiexp.ss.uci.edu/research/papers/SteyversGriffithsLSABookFormatted.pdf

[13] Each grant was categorized by Program Staff according to its major focus. These categorizations were vetted by the assigned Program Director for each grant, and all category assignments were subsequently reviewed by a single member of the internal planning team for consistency and accuracy.

NINDS grants data are juxtaposed to SfN abstract data (described above), with NIH funding sources indicated in different colors. These data give an indication of the relative contributions of various NIH institutes to specific scientific topics (bottom), and place relative NINDS funding levels (top) within the context of overall NIH support for any given category. Note that a few categories were modified in order to be more reflective of NINDS research, and some were combined in order to simplify the Figures:

**Figure 11. Distribution across SfN Themes**

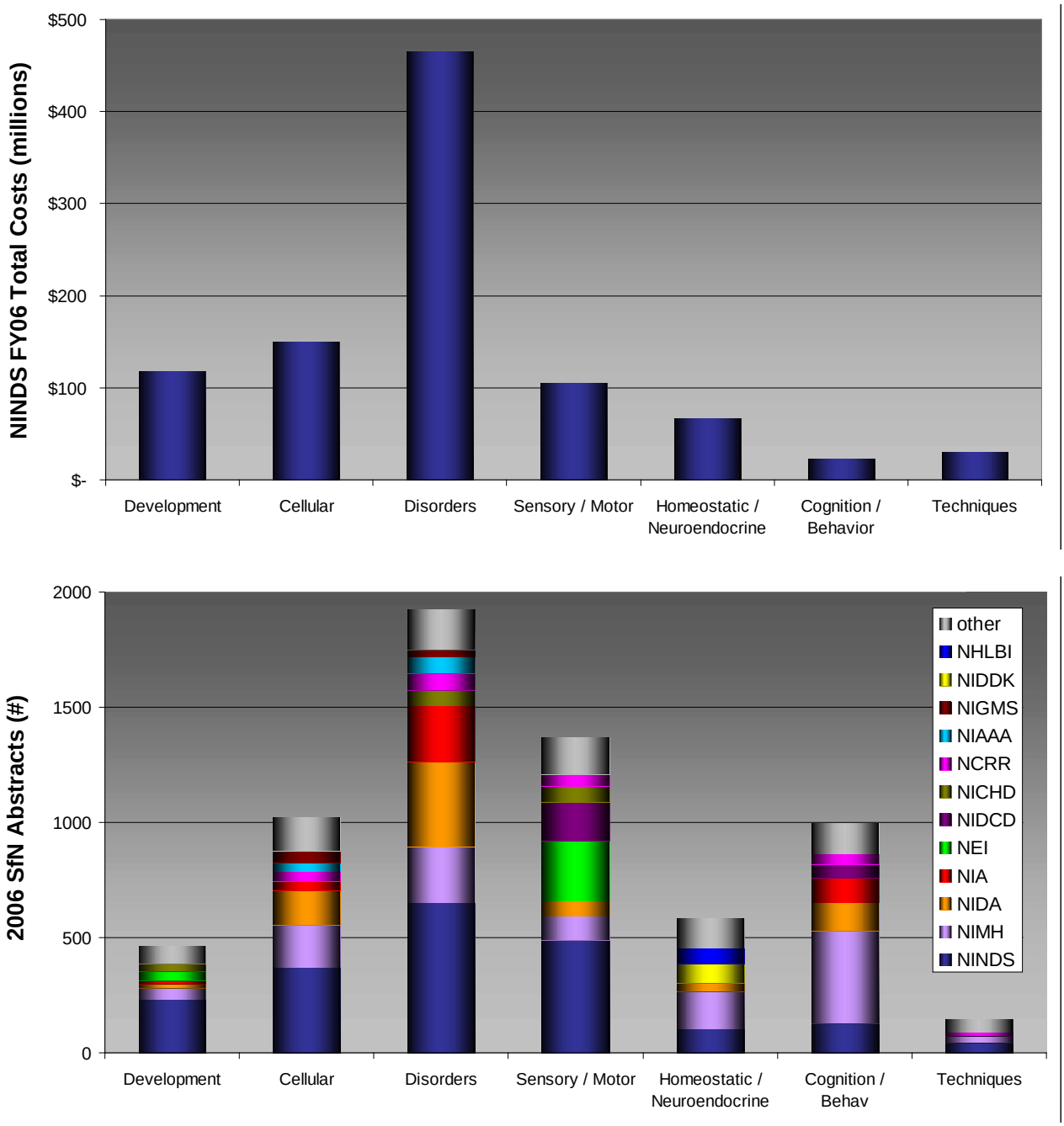
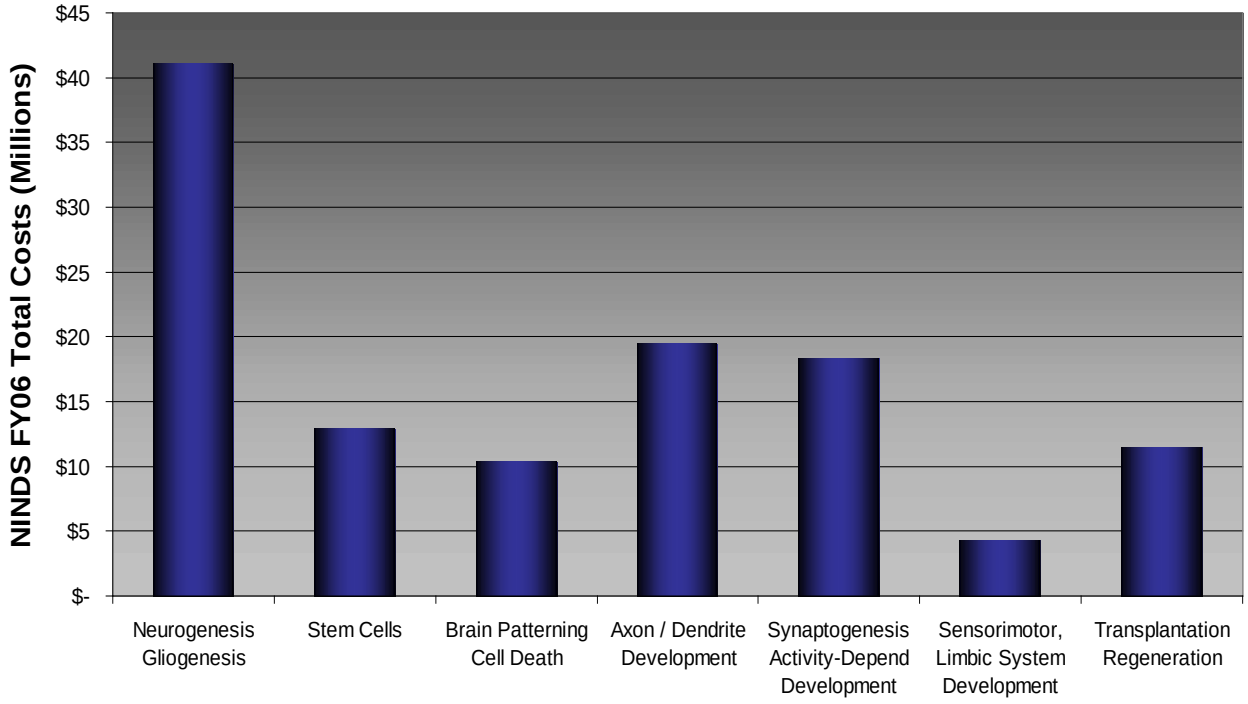


**Figure 12. Distribution across the SfN Theme: Developmental Neuroscience**



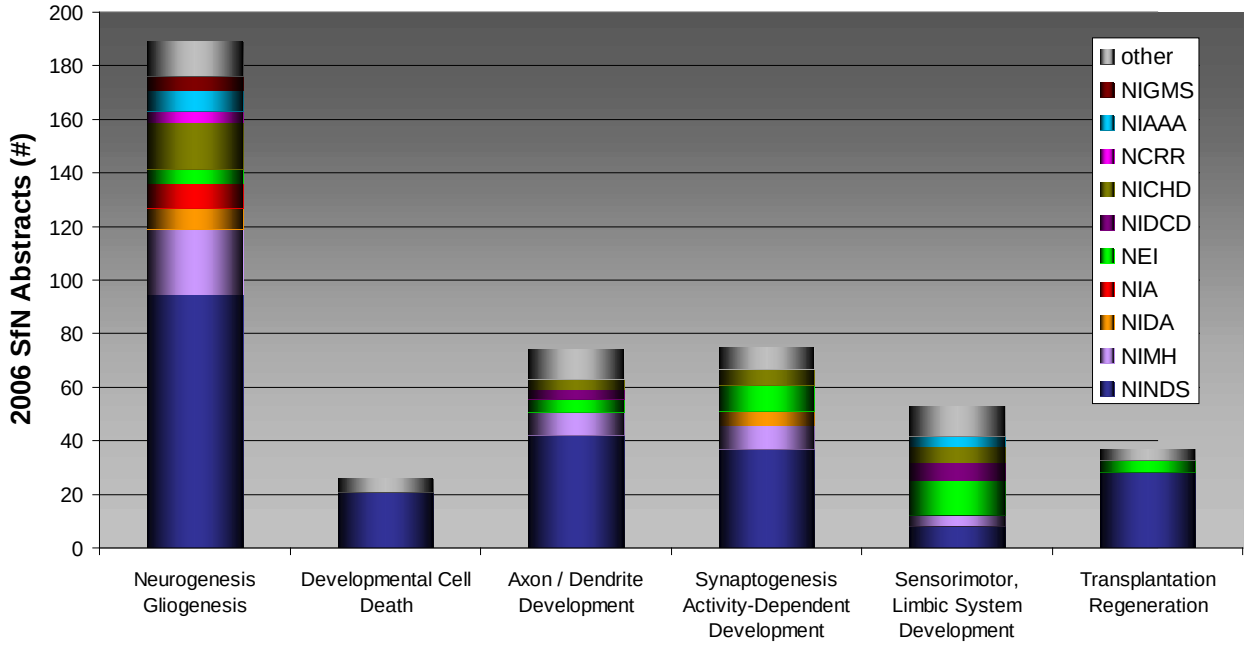
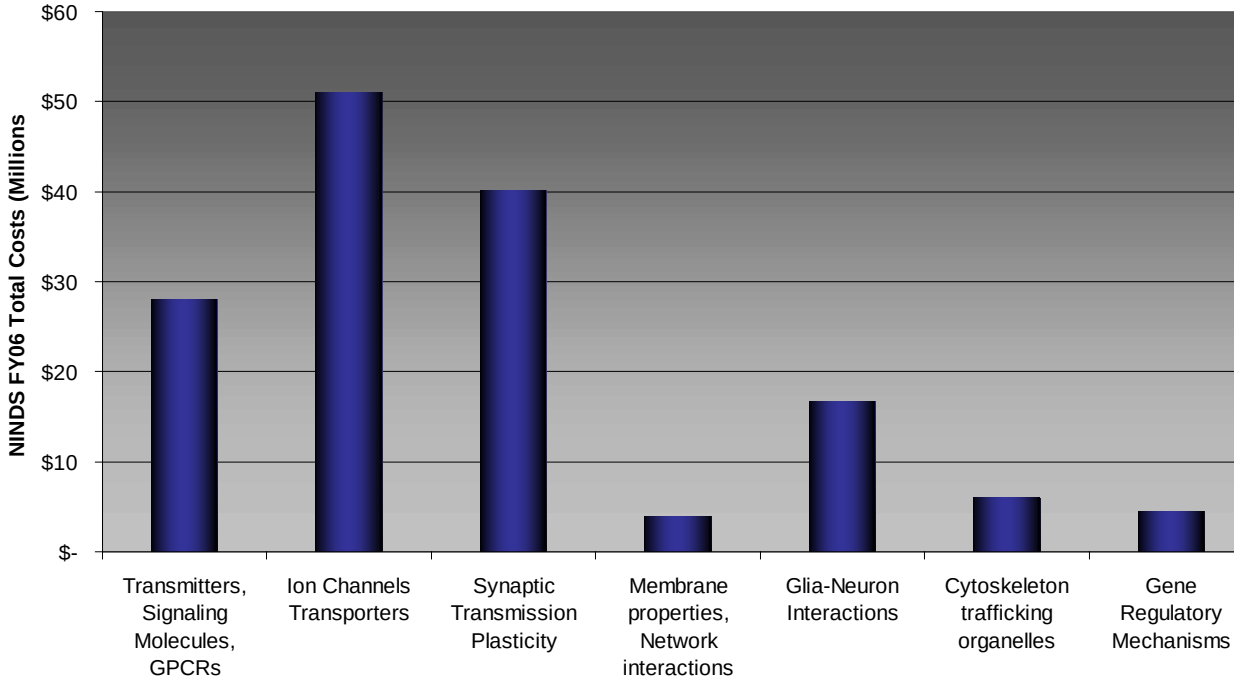



**Figure 13. Distribution across the SfN Theme: Cellular Neuroscience**



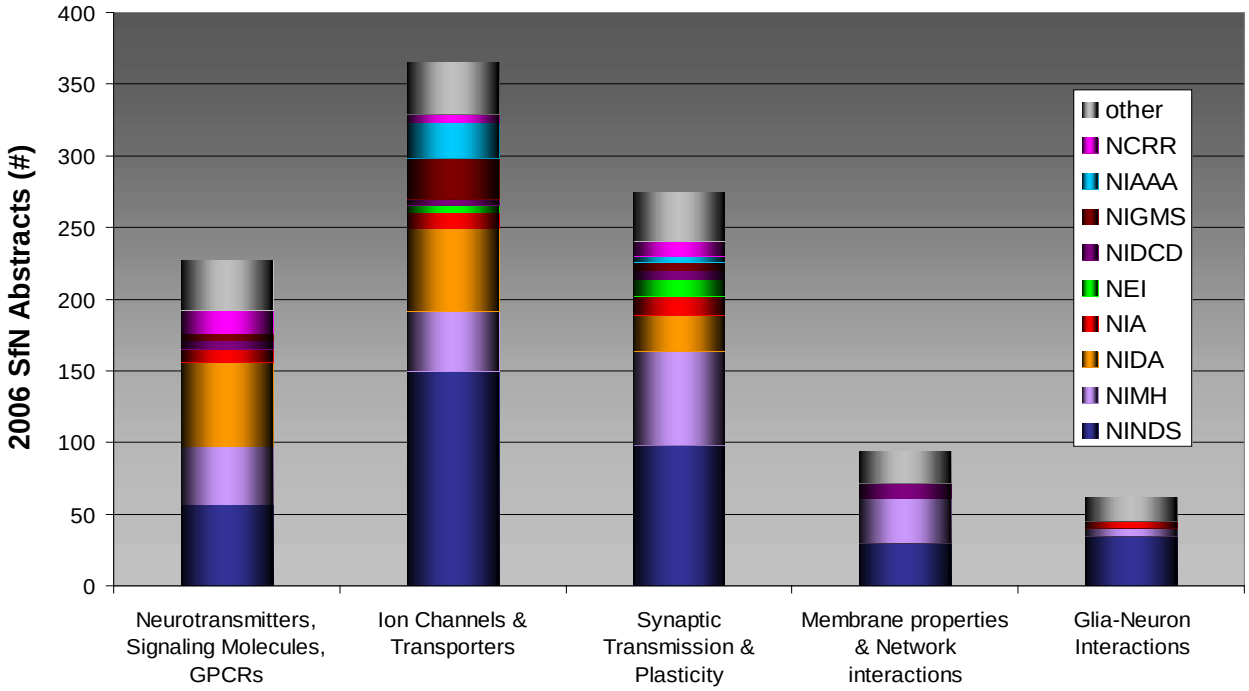
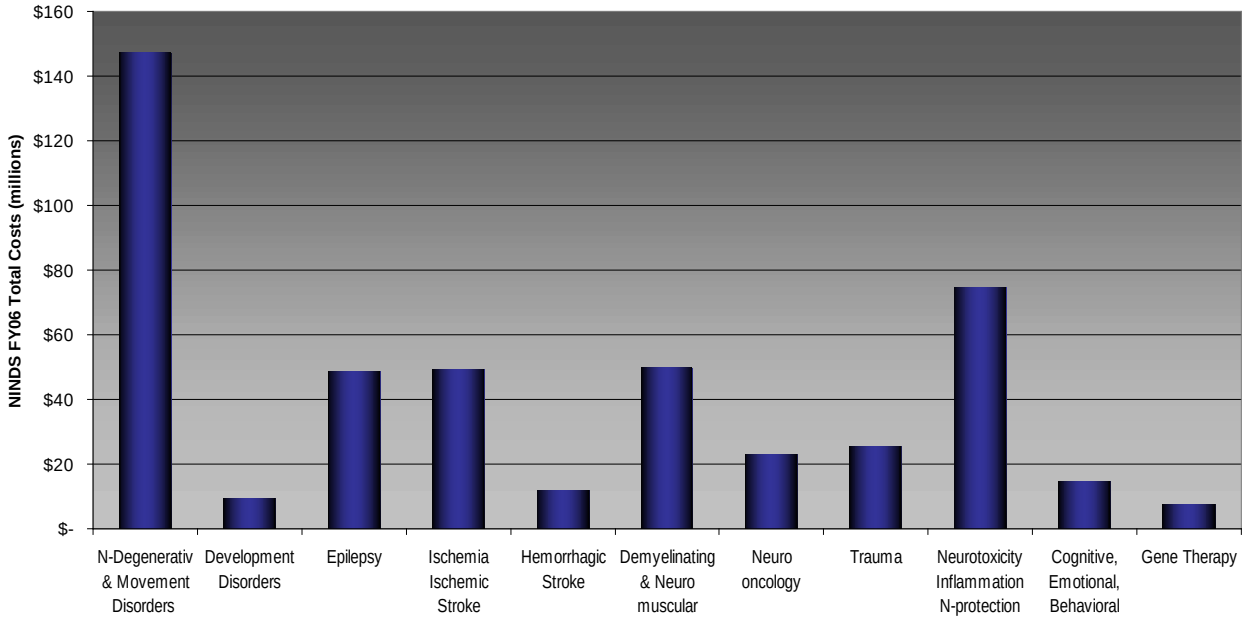



**Figure 14. Distribution across the SfN Theme: Neurological Disorders**



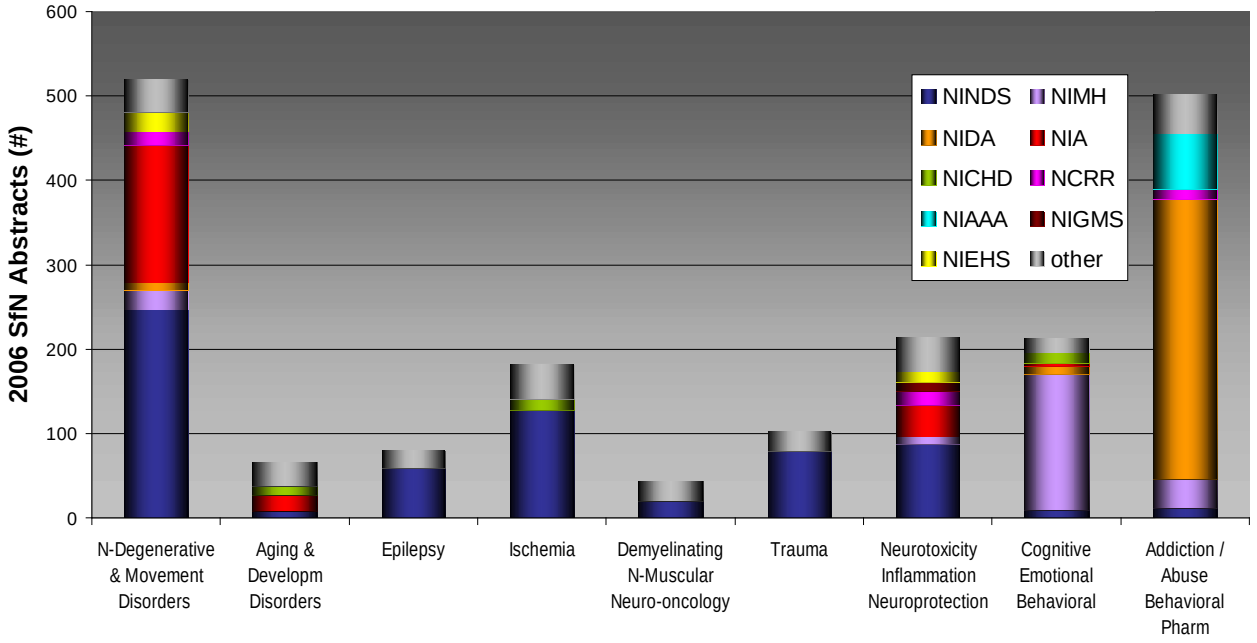
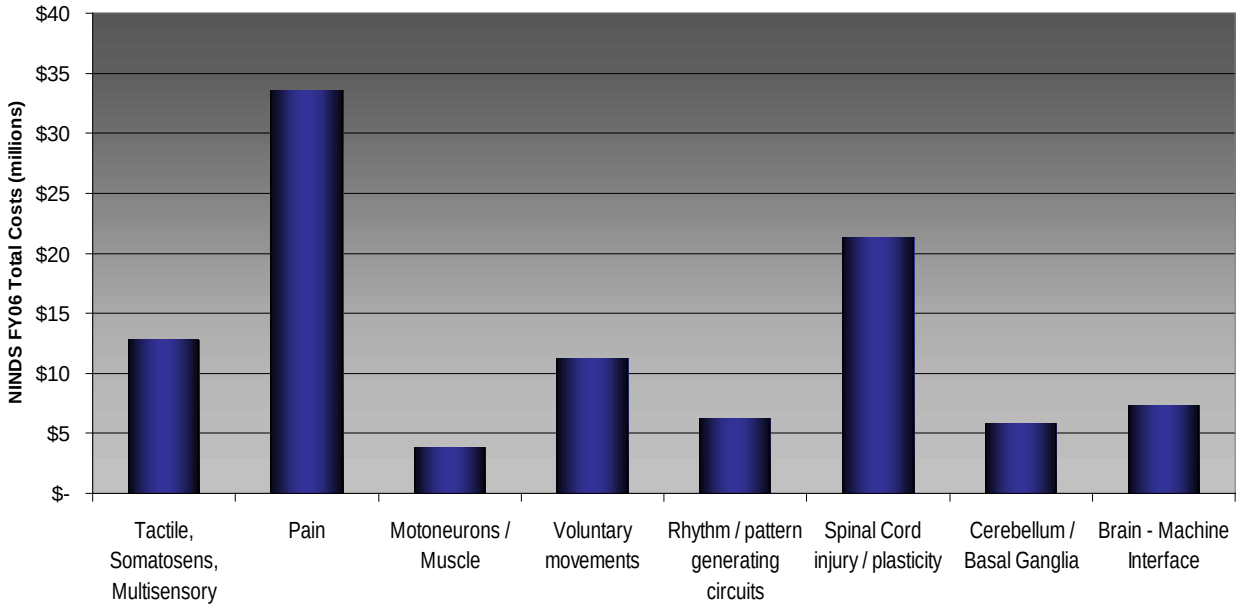



**Figure 15. Distribution across the SfN Theme: Sensory-Motor Biology**



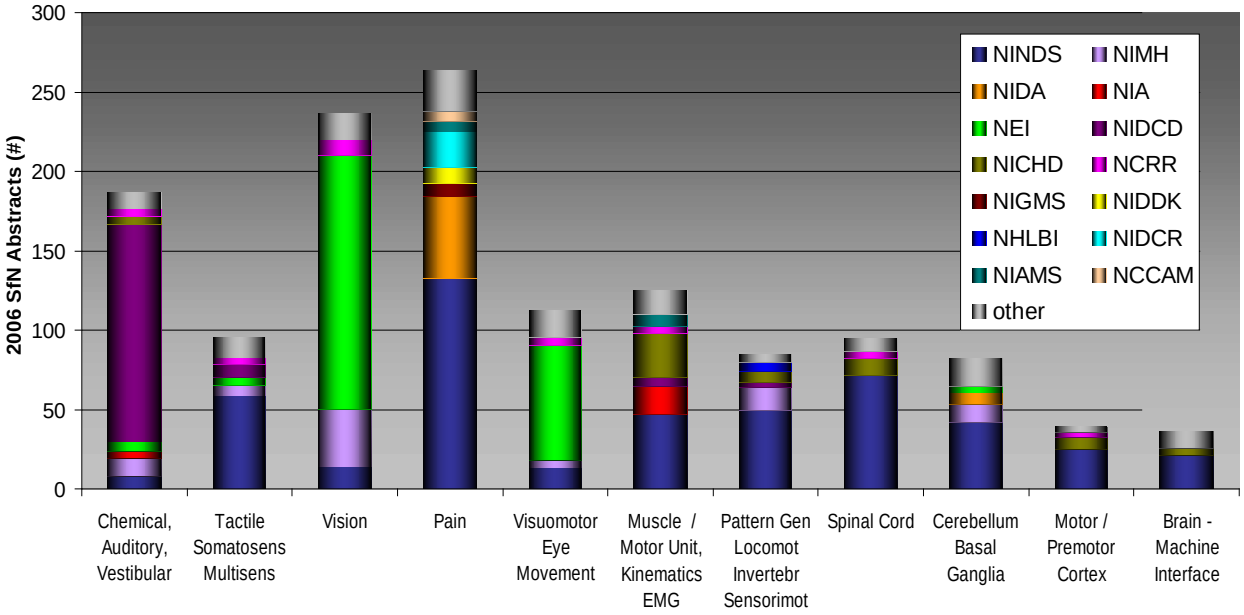
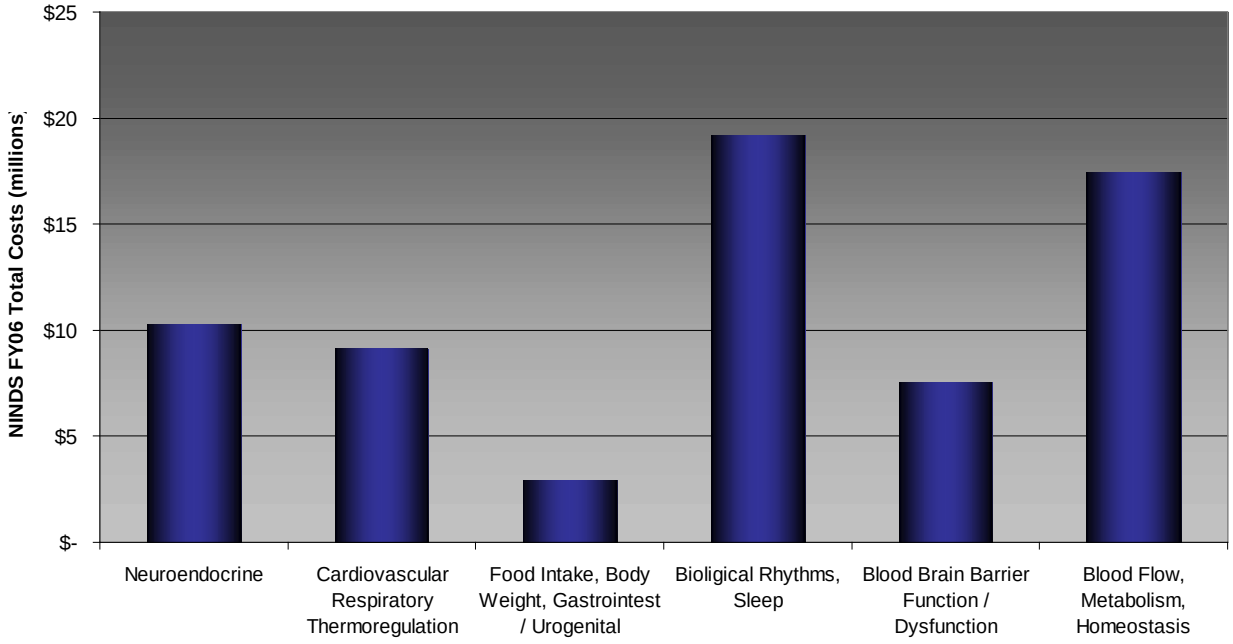



**Figure 16. Distribution across the SfN Theme: Homeostatic/Neuroendocrine Neuroscience**



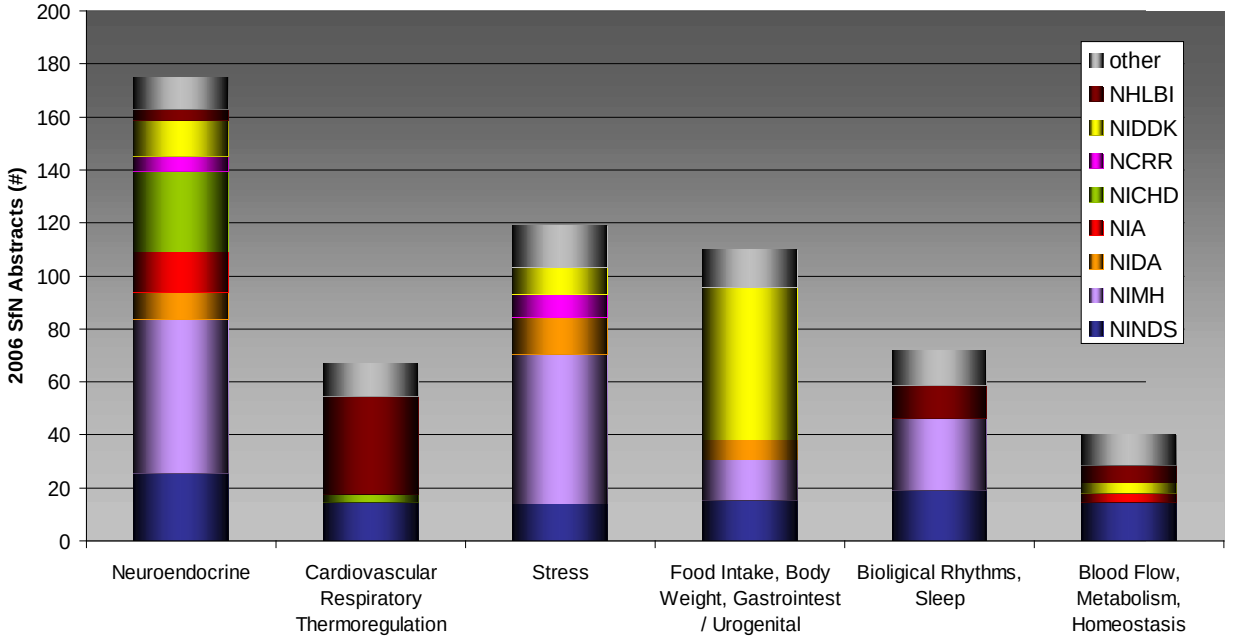
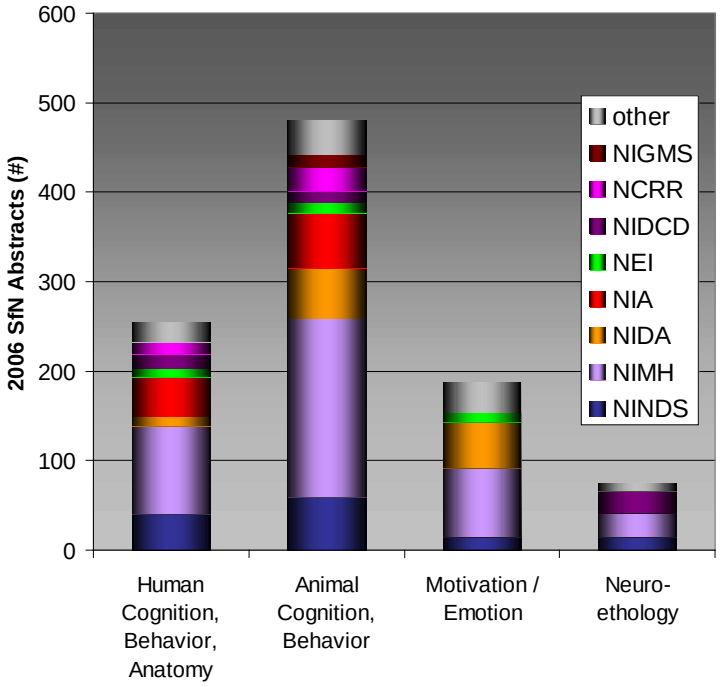



**Figure 17. Distribution across the SfN Theme: Cognitive Neuroscience**



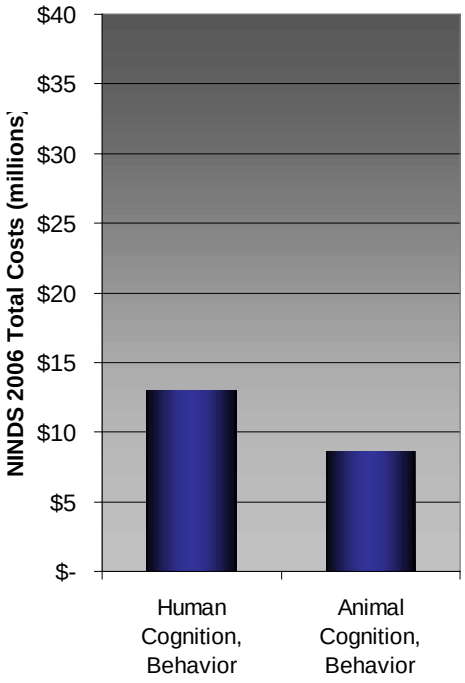
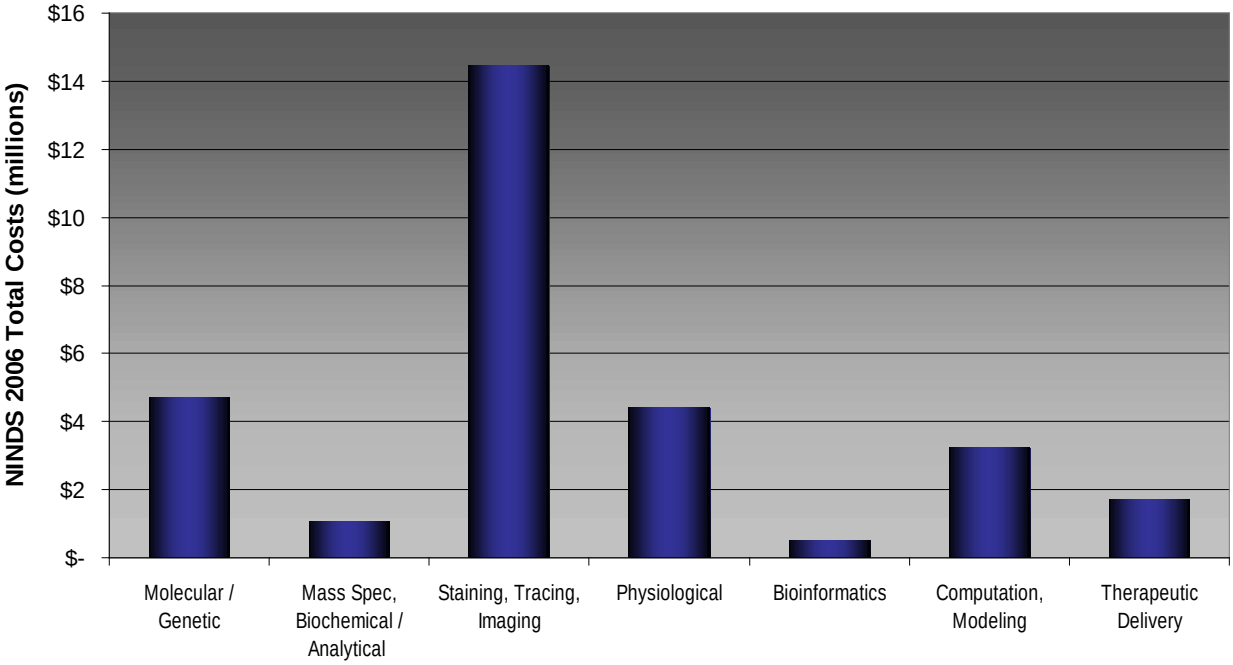
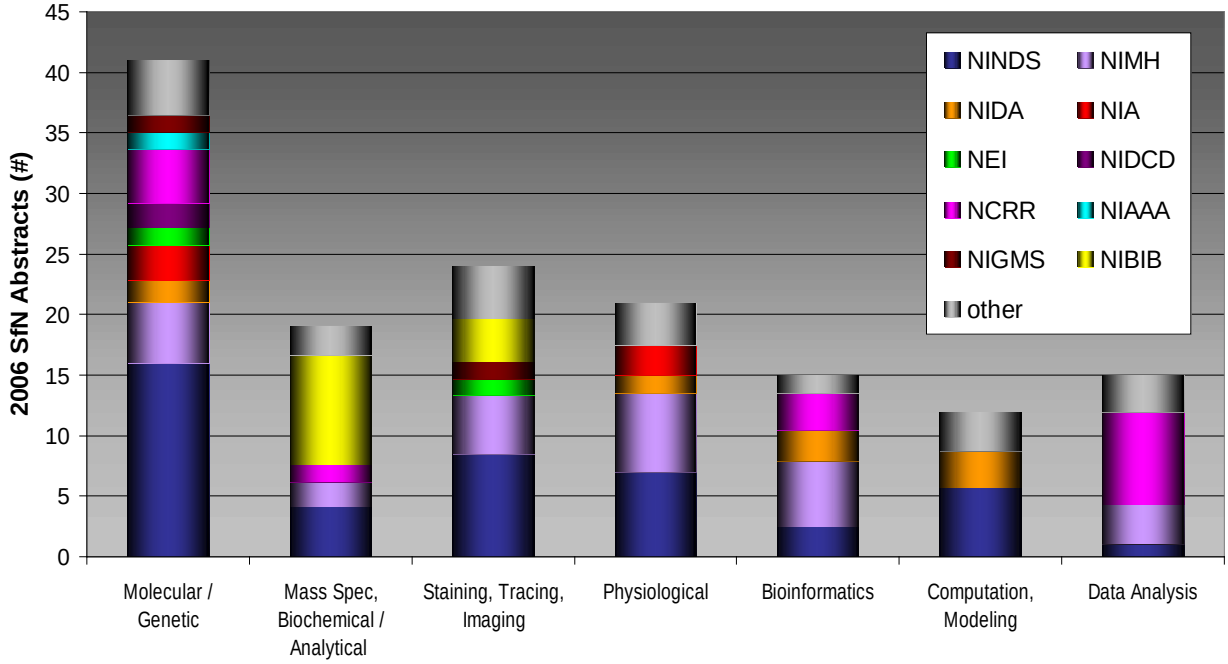



**Figure 18. Distribution across the SfN Theme: Techniques**



# III. Funding Mechanisms

## A. Five Year Funding Trends for R01 Awards – Comparisons across NIH Institutes

Historical R01 Success Rates – 2003-2008

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 5 year change |
|---|---|---|---|---|---|---|---|
| NINDS | 29.7 | 26.3 | 22.2 | 19.0 | 18.8 | 21.7 | (8.0) |
| NIMH | 25.5 | 25.3 | 20.6 | 19.6 | 23.7 | 20.4 | (5.1) |
| NIDA | 32.9 | 26.4 | 21.8 | 18.7 | 22.3 | 24.9 | (8.0) |
| NIA | 28.5 | 19.0 | 17.3 | 17.0 | 22.1 | 21.8 | (6.7) |
| NEI | 34.4 | 31.7 | 27.8 | 25.1 | 30.0 | 31.9 | (2.5) |
| NICHD | 24.7 | 15.4 | 15.3 | 14.0 | 21.2 | 17.4 | (7.3) |
| NIAAA | 28.7 | 26.2 | 31.0 | 25.0 | 26.7 | 25.6 | (3.1) |
| NIDCD | 42.0 | 35.6 | 27.4 | 28.8 | 33.2 | 30.8 | (11.2) |
| | | | | | | | |
| NCI | 26.2 | 24.4 | 20.1 | 18.9 | 20.9 | 21 | (5.2) |
| NIAID | 33.6 | 24.1 | 23.9 | 20.7 | 18.7 | 20.7 | (12.9) |
| NHLBI | 32.6 | 27.2 | 22.1 | 19.7 | 21.8 | 23.2 | (9.4) |
| NIGMS | 37.3 | 29.3 | 26.4 | 26.2 | 33.1 | 27 | (10.3) |
| NIDDK | 31.6 | 25.2 | 24.8 | 20.3 | 23.8 | 24.2 | (7.4) |

*Success Rate is defined as the ratio between funded vs. reviewed competing applications. Applications with one or more amendment in the same fiscal year are only counted once.*

Number of R01 Submissions

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 5 year change |
|---|---|---|---|---|---|---|---|
| NINDS | 1961 | 2258 | 2320 | 2401 | 2149 | 2062 | 5% |
| NIMH | 1531 | 1665 | 1705 | 1661 | 1697 | 1605 | 5% |
| NIDA | 887 | 1075 | 1142 | 1241 | 1146 | 980 | 10% |
| NIA | 885 | 1176 | 1182 | 1344 | 1152 | 977 | 10% |
| NEI | 684 | 792 | 805 | 846 | 714 | 699 | 2% |
| NICHD | 1286 | 1645 | 1748 | 1535 | 1360 | 1289 | 0% |
| NIAAA | 383 | 439 | 429 | 376 | 378 | 429 | 12% |
| NIDCD | 407 | 438 | 514 | 511 | 497 | 451 | 11% |
| | | | | | | | |
| NCI | 3726 | 4071 | 4134 | 4310 | 3792 | 3771 | 1% |
| NIAID | 2077 | 2580 | 2681 | 2829 | 2722 | 2580 | 24% |
| NHLBI | 2913 | 3151 | 3334 | 3529 | 3332 | 3291 | 13% |
| NIGMS | 2658 | 2884 | 3104 | 3123 | 3025 | 3098 | 17% |
| NIDDK | 1866 | 2311 | 2162 | 2372 | 2089 | 1906 | 2% |

## Number of Competing R01 Awards

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | 5 year change |
|---|---|---|---|---|---|---|---|---|
| NINDS | 582 | 593 | 514 | 456 | 405 | 447 | | -23% |
| NIMH | 390 | 422 | 351 | 325 | 402 | 328 | | -16% |
| NIDA | 292 | 284 | 249 | 232 | 256 | 244 | | -16% |
| NIA | 252 | 223 | 205 | 228 | 255 | 213 | | -15% |
| NEI | 235 | 251 | 224 | 212 | 214 | 223 | | -5% |
| NICHD | 318 | 254 | 268 | 215 | 288 | 224 | | -30% |
| NIAAA | 110 | 115 | 133 | 94 | 101 | 110 | | 0% |
| NIDCD | 171 | 156 | 141 | 147 | 165 | 139 | | -19% |
| | | | | | | | | |
| NCI | 977 | 992 | 831 | 816 | 792 | 793 | | -19% |
| NIAID | 697 | 621 | 641 | 585 | 508 | 533 | | -24% |
| NHLBI | 949 | 856 | 738 | 695 | 727 | 764 | | -19% |
| NIGMS | 991 | 845 | 821 | 818 | 1000 | 838 | | -15% |
| NIDDK | 589 | 582 | 537 | 481 | 498 | 462 | | -22% |

## Extramural Grants Budgets 2003-2008

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | 5 year change |
|---|---|---|---|---|---|---|---|---|
| NINDS | 1,204.0 | 1,236.9 | 1,277.4 | 1,244.6 | 1,259.2 | 1,270.4 | | 5.5% |
| NIMH | 1,039.7 | 1,089.9 | 1,111.4 | 1,082.9 | 1,084.1 | 1,113.2 | | 7.1% |
| NIDA | 734.7 | 750.8 | 759.4 | 749.9 | 760.7 | 763.0 | | 3.9% |
| NIA | 802.0 | 831.7 | 845.5 | 831.3 | 836.4 | 834.1 | | 4.0% |
| NEI | 514.0 | 534.7 | 541.7 | 538.5 | 537.5 | 537.1 | | 4.5% |
| NICHD | 873.8 | 890.8 | 885.8 | 872.8 | 881.8 | 882.1 | | 1.0% |
| NIAAA | 319.2 | 328.8 | 332.0 | 327.8 | 331.1 | 332.4 | | 4.1% |
| NIDCD | 305.1 | 313.3 | 321.8 | 316.0 | 317.7 | 317.6 | | 4.1% |
| | | | | | | | | |
| NCI | 2,990.8 | 3,116.0 | 3,194.0 | 3,169.9 | 3,115.8 | 3,076.9 | | 2.9% |
| NIAID | 2,267.8 | 2,366.6 | 2,594.3 | 2,542.1 | 2,542.9 | 2,513.9 | | 10.9% |
| NHLBI | 2,249.8 | 2,342.6 | 2,396.6 | 2,363.3 | 2,354.4 | 2,309.9 | | 2.7% |
| NIGMS | 1,735.8 | 1,813.5 | 1,822.2 | 1,802.7 | 1,814.3 | 1,820.6 | | 4.9% |
| NIDDK | 1,392.2 | 1,516.9 | 1,522.8 | 1,480.0 | 1,452.1 | 1,417.1 | | 1.8% |

## Total Cost per R01 (thousands)

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | 5 year change |
|---|---|---|---|---|---|---|---|---|
| **NINDS** | 361.3 | 359.6 | 390.2 | 339.4 | 367.0 | 383.6 | | **6%** |
| **NIMH** | 383.8 | 365.6 | 368.7 | 388.9 | 425.3 | 475.6 | | **24%** |
| **NIDA** | 397.0 | 382.8 | 394.9 | 389.7 | 441.1 | 455.3 | | **15%** |
| **NIA** | 394.6 | 356.4 | 353.5 | 357.3 | 379.3 | 419.5 | | **6%** |
| **NEI** | 365.1 | 364.8 | 395.1 | 392.3 | 401.0 | 425.6 | | **17%** |
| **NICHD** | 334.6 | 379.8 | 344.5 | 354.5 | 396.8 | 420.6 | | **26%** |
| **NIAAA** | 398.5 | 349.6 | 388.2 | 379.7 | 410.7 | 412.7 | | **4%** |
| **NIDCD** | 350.8 | 348.3 | 362.1 | 361.6 | 359.3 | 393.0 | | **12%** |
| | | | | | | | | |
| **NCI** | 343.8 | 331.9 | 331.0 | 319.2 | 349.6 | 375.0 | | **9%** |
| **NIAID** | 258.4 | 350.1 | 352.1 | 388.8 | 380.5 | 403.3 | | **56%** |
| **NHLBI** | 381.6 | 388.7 | 413.7 | 435.3 | 475.4 | 467.5 | | **23%** |
| **NIGMS** | 319.5 | 312.1 | 310.9 | 312.0 | 326.6 | 342.6 | | **7%** |
| **NIDDK** | 341.3 | 323.6 | 334.5 | 330.6 | 335.5 | 364.6 | | **7%** |

**Biomedical Research and Development Price Index**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | Purchasing Power |
|---|---|---|---|---|---|---|---|---|
| **BRDPI** | 3.50% | 3.70% | 3.90% | 4.60% | 3.90% | 3.50% | | **-17.50%** |

## R01 Budget (millions)

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | 5 year change |
|---|---|---|---|---|---|---|---|---|
| **NINDS** | 813.8 | 836.0 | 822.3 | 798.8 | 761.8 | 730.3 | | **-10.2%** |
| **NIMH** | 620.6 | 646.1 | 647.1 | 621.7 | 633.7 | 639.6 | | **3.1%** |
| **NIDA** | 466.6 | 479.4 | 473.9 | 465.2 | 467.5 | 464.4 | | **-0.5%** |
| **NIA** | 394.8 | 398.1 | 388.2 | 379.3 | 376.2 | 374.6 | | **-5.1%** |
| **NEI** | 356.3 | 367.4 | 373.5 | 372.6 | 380.6 | 378.7 | | **6.3%** |
| **NICHD** | 437.1 | 440.7 | 438.0 | 416.7 | 430.0 | 426.4 | | **-2.4%** |
| **NIAAA** | 190.0 | 190.1 | 192.6 | 194.3 | 196.8 | 195.8 | | **3.0%** |
| **NIDCD** | 223.4 | 238.6 | 249.4 | 245.3 | 246.6 | 243.9 | | **9.2%** |
| | | | | | | | | |
| **NCI** | 1,227.2 | 1,312.1 | 1,354.5 | 1,333.4 | 1,305.9 | 1,287.4 | | **4.9%** |
| **NIAID** | 885.3 | 983.8 | 1,022.9 | 1,044.9 | 1,023.7 | 994.6 | | **12.3%** |
| **NHLBI** | 1,262.8 | 1,329.0 | 1,328.4 | 1,323.5 | 1,294.6 | 1,306.8 | | **3.5%** |
| **NIGMS** | 1,098.0 | 1,122.4 | 1,131.6 | 1,109.9 | 1,121.8 | 1,138.8 | | **3.7%** |
| **NIDDK** | 752.5 | 793.7 | 792.3 | 765.1 | 748.8 | 725.5 | | **-3.6%** |

## R01 Budget (% of Extramural Grants Budget)

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | 5 year change |
|---|---|---|---|---|---|---|---|---|
| **NINDS** | 67.6% | 67.6% | 64.4% | 64.2% | 60.5% | 57.5% | | **-10.1%** |
| **NIMH** | 59.7% | 59.3% | 58.2% | 57.4% | 58.5% | 57.5% | | **-2.2%** |
| **NIDA** | 63.5% | 63.9% | 62.4% | 62.0% | 61.5% | 60.9% | | **-2.6%** |
| **NIA** | 49.2% | 47.9% | 45.9% | 45.6% | 45.0% | 44.9% | | **-4.3%** |
| **NEI** | 69.3% | 68.7% | 68.9% | 69.2% | 70.8% | 70.5% | | **1.2%** |
| **NICHD** | 50.0% | 49.5% | 49.4% | 47.7% | 48.8% | 48.3% | | **-1.7%** |
| **NIAAA** | 59.5% | 57.8% | 58.0% | 59.3% | 59.4% | 58.9% | | **-0.6%** |
| **NIDCD** | 73.2% | 76.2% | 77.5% | 77.6% | 77.6% | 76.8% | | **3.6%** |
| | | | | | | | | |
| **NCI** | 41.0% | 42.1% | 42.4% | 42.1% | 41.9% | 41.8% | | 0.8% |
| **NIAID** | 39.0% | 41.6% | 39.4% | 41.1% | 40.3% | 39.6% | | 0.5% |
| **NHLBI** | 56.1% | 56.7% | 55.4% | 56.0% | 55.0% | 56.6% | | 0.4% |
| **NIGMS** | 63.3% | 61.9% | 62.1% | 61.6% | 61.8% | 62.6% | | -0.7% |
| **NIDDK** | 54.1% | 52.3% | 52.0% | 51.7% | 51.6% | 51.2% | | -2.9% |

*Sources: 2003-2007 Comparative data compiled from the NIH OER website: http://report.nih.gov/index.aspx?section=NIHFunding (2003 NINDS data from NINDS FINeX Budget tables). 2008 data from NIH OER preliminary report.*

## B. Analysis of Publication Output using Electronic Scientific Portfolio Assistant (eSPA)

eSPA is a new productivity analysis software tool developed by the company Discovery Logic through support from the National Institute of Allergy and Infectious Diseases (NIAID). This tool links NIH-funded grants to publications citing these grants in Medline and the ISI database from Thomson Scientific. In addition, the ISI database provides citation statistics for each publication, and impact factor information on each journal. These linkages allow users of the software to assess publication output of different categories of NIH grants.

We used this software on a trial basis to examine the relative reported outputs of NINDS-funded P50, P01 and R01 grants initiated between 1996 and 2002. Table 1 shows the number of new grants (not including competing renewals) initiated in each year for the indicated grant mechanisms. For each year, both the total and currently active grants are indicated. Only currently active grants (totals indicated in red) were included in the productivity analysis, since published citations of grants become more variable after grant termination.

| | P50 | | P01 | | R01 | |
|---|---|---|---|---|---|---|
| | Active | Total | Active | Total | Active | Total |
| 1996 | 2 | 3 | 4 | 11 | 55 | 260 |
| 1997 | 5 | 6 | 4 | 7 | 66 | 222 |
| 1998 | 2 | 2 | 1 | 3 | 68 | 228 |
| 1999 | 5 | 5 | 5 | 8 | 122 | 374 |
| 2000 | 1 | 1 | 4 | 10 | 122 | 391 |
| 2001 | 0 | 0 | 2 | 5 | 106 | 364 |
| 2002 | 4 | 4 | 3 | 5 | 101 | 352 |
| ALL | 19 | 21 | 23 | 49 | 640 | 2191 |

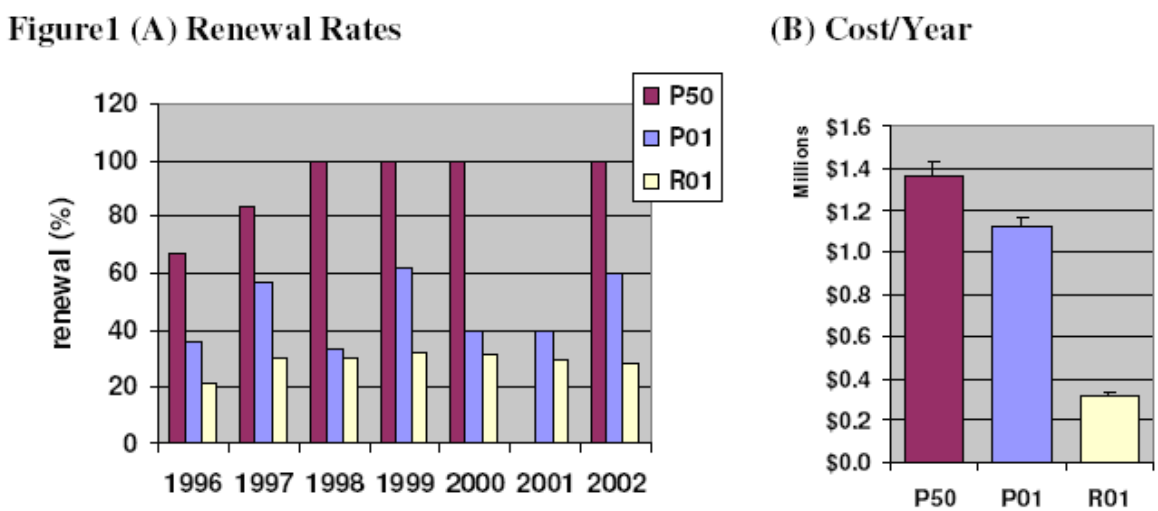



**Figure 1.** (**A**) Renewal rates for each grant mechanism initiated in the indicated years were calculated as ratios between currently active and total initiated (see Table 1). Average renewal rates were much higher for P50 (92%) and P01 (47%) than for R01 (29%). (**B**) Average annual cost for grants included in the productivity analysis (i.e., currently active grants). R01s cost on average $300,000, P50s and P01s were approximately 3 to 4 times more expensive.

For the eSPA productivity analysis, we excluded two sets of data outliers, specifically, 15 currently active R01 awards (i.e., grants that have been competitively renewed) with no cited publications, and one P01 grant that cited only two publications. In both cases, a manual check of Medline indicated that investigators had failed to cite publications related to the grants.

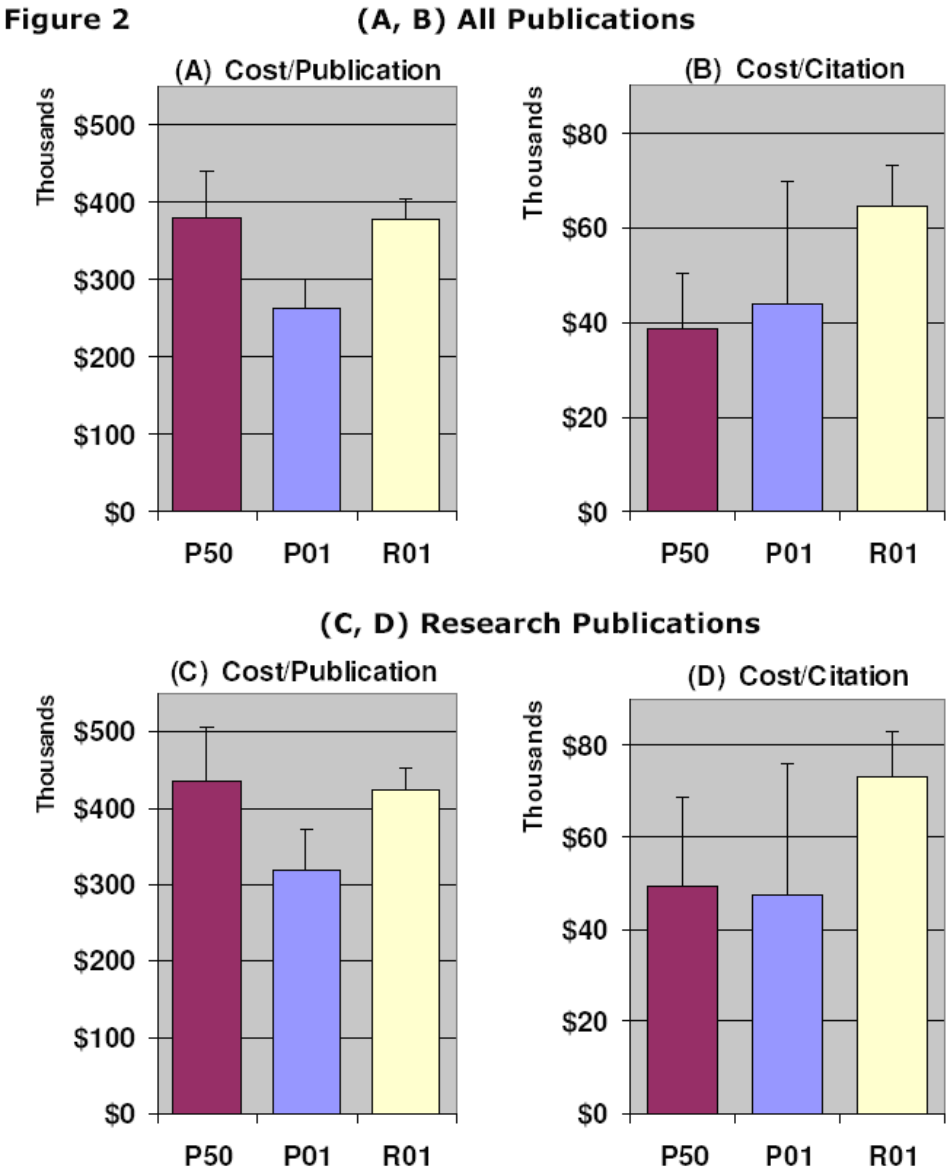



**Figure 2** shows the output cost analysis for each grant mechanism. Data are averages ± SEM. Costs are calculated from total funding data divided by (A, C) total # publications, (B, D) total # of citations (self-citations excluded). (A, B) are data with all publications included. (C, D) are data for research publications only.

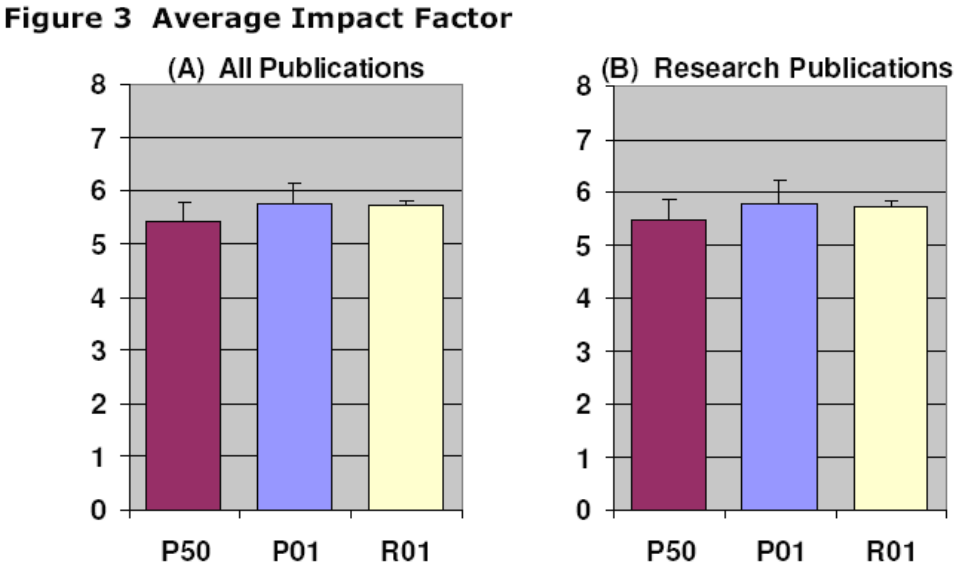



**Figure 3.** Averaged impact factors of publications citing grants for each mechanism. There were no differences between grant mechanisms; moreover, exclusion of non-research publications as indicated for each publication in Medline) did not significantly change the averages.

# IV. Research Resources

## A. NINDS Research Resources for FY08

**Molecular Genetics Tools:**

- *Gene Expression Nervous System Atlas (GENSAT)* – A contract to generate transgenic mice expressing fluorescent proteins in specific cell types, and more recently, mouse lines expressing cre recombinase. In addition to the indicated NINDS allocation, NIMH has contributed substantially to this project, monetarily and through participation of the NIMH Intramural program (laboratory of Chip Gerfen).
- *UC Davis NeuroMab Hybridoma Facility* – NeuroMab supports the production and characterization of monoclonal antibodies optimized for use in mammalian brain. In addition to the indicated amount, the project was significantly expanded in 2007 with contributions from the NIH Blueprint for antibodies for the study of neurodevelopment, and from the NIH Roadmap for antibodies for epigenetic studies.
- *Knock-Out Mouse Project (KOMP)* – This is a trans-NIH effort with partial support from NINDS to establish a public library of mouse ES cells with null mutations in all genes.
- *Neuroscience Microarray Consortium* – These cooperative agreements support gene expression profiling of the nervous system. NINDS administers the grants and is the main source of funds for all centers but other ICs and Blueprint contribute support as well. The Consortium is composed of the following centers:
    - *TGen Microarray Center for Research on the Nervous System*
    - *Yale Microarray Center for Research on the Nervous System*
    - *UCLA NINDS/NIMH Microarray Center*
    - *Duke Neurosciences Microarray Center*
- *Scan of Protein Space for Optical Voltage Probes* – A cooperative agreement to produce fluorescent protein-based voltage sensors for use in the mammalian brain.

**Neuroinformatics, Instrumentation, and Imaging**

- *Neuroimaging Informatics Tools and Resources Clearinghouse (NITRC)* – NINDS administers some contracts for this Blueprint project, which collects and points to standardized software and informatics tools for neural imaging.
- *Pediatric MRI Study*- A set of contracts supported by NINDS, NICHD, NIDA, NIMH, and Blueprint to develop a database of MRI and correlated clinical/behavioral data from 500 healthy children (newborn to teens).
- *Neuroscience Information Framework* – An ongoing contract, in conjunction with the Society for Neuroscience's Neuroscience Database Gateway, to create a public online inventory of neuroscience resources around the world.
- *Chronic Microelectrode Arrays* – Two separate contracts to develop implantable microelectrode array technologies for chronic *in vivo* wireless recording.

**Tissue Banks and Repositories:**

- *Coriell Genetic Resource Center* - This contract supports a repository for human blood, DNA, and cell samples and genetic and clinical data from disease and control subjects.
- *Harvard Brain Tissue Resource Center (HBTRC)* – The center acquires, processes, stores and distributes high quality postmortem brain tissue to the neuroscience community. This is primarily an NIMH grant to which NINDS has contributed in the past.

- *The National NeuroAIDS Tissue Consortium (NNTC)* – Supported by NIMH and NINDS, the consortium collects, stores, and distributes nervous tissue, cerebrospinal fluid, blood, and other tissue from HIV-infected individuals. NINDS contributes to the following sites:
    - *Texas Repository for AIDS Neuropathogenesis Research*
    - *UCLA National Neurological AIDS Bank (NNAB)*
- *UCLA Human Brain and Spinal Fluid Resource Center* – A repository of blood, cerebrospinal fluid, and postmortem nervous system tissue available for research.

**Clinical, Therapeutic, or Diagnostic Tools:**

- *NIH Toolbox for Assessment of Neurological and Behavioral Function* – The toolbox will be a comprehensive set of measures for assessing cognition, emotion, sensation and motor functions in human subjects, with an emphasis on those measures that are useful for studying epidemiology, prevention, and long-term intervention.

**Center Core Grants:**

- *Center Core Grants (P30)* – This mechanism provides support for the establishment and maintenance of centralized tools and facilities shared by teams of investigators. Multi-disciplinary efforts are encouraged.
- *Neuroscience Interdisciplinary Core Grants* – Support interdisciplinary centralized resources and facilities shared by neuroscience investigators

## B. NINDS SBIR/STTR Awards Related to the Development of Resources (2007)

The Small Business Technology Transfer (STTR) and Innovation Research (SBIR) Programs are congressionally mandated and require 0.3% and 2.5% of the NIH extramural R&D budget respectively. The total NINDS SBIR/STTR budget for 2007 was $42,045,538. A significant portion of the SBIR awards are devoted to developing tools and resources that may advance research approaches. Below we list the resource-developing SBIR awards for fiscal year 2007. The majority of these projects focus on developing better electrodes, probes, or brain imaging technologies.

| Actv | PI Name(s) All | Institution | Title | Awd Tot $ |
|---|---|---|---|---|
| R44 | BARBOUR, RANDALL LOCKE | PHOTON MIGRATION TECHNOLOGIES CORP | Functional Brain Imaging by Optical Tomography | 396758 |
| R41 | BARBOUR, RANDALL LOCKE | PHOTON MIGRATION TECHNOLOGIES CORP | Functional Imaging of Freely Moving Animals | 253514 |
| R44 | ECKHARDT, HELMUT | PREMITEC, INC. | Insulating Coatings for Implant Devices and Ribbon Cables | 806135 |
| R43 | ENTINE, GERALD | RADIATION MONITORING DEVICES, INC. | Solid-State Photosensor for PET | 100000 |
| R44 | JOHNSON, DAVID A | PINNACLE TECHNOLOGY, INC | Glutamate Biosensors for Ischemia In Vivo and Tissue Studies | 385052 |
| R44 | KRAMER, KEVIN M. | ADVANCED MEDICAL ELECTRONICS CORPORATION | Wireless System-on-a-Chip EEG IC For Animal Studies | 632815 |
| R43 | LANNING, BRUCE | ITN ENERGY SYSTEMS, INC. | Wireless Multi-Modal Brain Monitoring | 104358 |
| R44 | LIANG, YIQING | CLEVER SYSTEMS, INC. | Digital Video Monitor and Analysis of Seizures with EEG | 518413 |
| R44 | NEMENOV, MIKHAIL I. | LASMED, LLC | Laser Diode for Ion Channel Stimulation | 609593 |

| | | | | |
|---|---|---|---|---|
| R44 | SAWYER, EVELYN | SEA RUN HOLDINGS, INC. | Salmon fibrin gels for surgical applications | 368467 |
| R44 | SHAH, KANAI S | RADIATION MONITORING DEVICES, INC. | High Resolution PET Detectors for Combined PET-MR Small Animal Imaging | 522226 |
| R41 | SIGWORTH, FREDERICK J | HARVARD BIOSCIENCE, INC. | Patch Clamp Amplifiers on a Chip | 134245 |
| R44 | SMITH, JACK R. | NEUROTRONICS, INC. | Extensible System for Disseminating Polysomnography Data | 385395 |
| R43 | SORENSEN, MICHAEL | SIMATRA MODELING TECHNOLOGIES, LLC | A low-cost, high-speed platform for neural modeling. | 183163 |
| R41 | STYNER, MARTIN ANDREAS | KITWARE, INC. | High Throughput web-base Image Analysis of Mouse Brain MR Imaging Studies | 197153 |
| R43 | TUCKER, TIMOTHY J | TUCKER-DAVIS TECHNOLOGIES, INC. | A High Throughput System for Multichannel Neurophysiology | 194905 |
| R44 | WELLS, JONATHON D | ACULIGHT CORPORATION | Development of an optical brain/nerve stimulator | 448456 |
| **Total** | | | | **6240648** |

# V. Training and Career Development

## A. Training and Career Development Support Mechanisms

More information on each program may be found here:
http://www.ninds.nih.gov/funding/areas/training_and_career_development/index.htm

**National Research Service Award (NRSA) Fellowships:**

- **F30 – Medical School Dual Degree (MD/PhD) Fellowship**
- **F31 – Individual Predoctoral Fellowship** - includes fellows supported through a general announcement for neuroscience graduate students, plus announcements for the NINDS Medical Student Scholars Program, and the NIH Predoctoral Fellowship Awards to Promote Diversity in Health-Related Research.
- **F32 – Individual Postdoctoral Fellowships**
- **T32 – Institutional NRSA** – includes broadly-based and highly-focused awards for postdoctoral and advanced predoctoral trainees.

**Career Development Awards:**

- **K01 – Mentored Research Scientist Development Award (MRSDA)** – used for three Programs: *MRSDA in Translational Research* (expiring in 2008), *Career Development Award to Promote Diversity in Neuroscience Research*, and *Re-Entry into the Neurological Sciences*. Eligible applicants include PhD or MD senior postdocs or junior faculty who come from groups that have been shown to be underrepresented in neuroscience research (Diversity K01) or who are seeking to re-enter research careers after an interruption due to family, illness, military, or clinical services (Re-entry K01).
- **K02 – Independent Scientist Award** – typically for physician-scientists who need extra support in order to obtain R01 funding following a K08 or K23 award.
- **K08 – Mentored Clinical Scientist Research Career Development Award** – for candidates with an MD or equivalent for the participation in a supervised training program in biomedical research.
- **K23 – Mentored Patient-Oriented Research Career Development Award** – for candidates with an MD or equivalent for supervised training in patient-oriented clinical research.
- **K24 – Midcareer Investigator Award in Patient-Oriented Research** – for clinical scientists who are actively engaged in patient-oriented research, are generally within 15 years of specialty training, and seek protected time to devote to patient-oriented research and to act as mentors for beginning clinical investigators.
- **K25 – Mentored Quantitative Research Career Development Award** – for fellows with quantitative scientific or engineering backgrounds who wish to enter the field of neuroscience.
- **K99/R00 – Pathway to Independence Award** – began in 2006, the program is designed to facilitate the transition from mentored to independent research positions, with a mentored (K99) phase that can last up to 2 years and a 3 year independent (R00) phase that is contingent upon securing an independent faculty position. In 2007 NINDS funded 10 awards, totaling $857,792 for the initial mentored phase.

**Other Programs:**

- **Loan Repayment Programs** - NINDS Supports the Clinical Research Loan Repayment Program and the Pediatric Loan Repayment Program, which facilitate the ability of health professionals who have substantial debt to significantly devote themselves to research, at the expense of more lucrative clinical practice. The goals of the programs are to recruit and retain highly qualified health professionals as clinical and pediatric investigators.

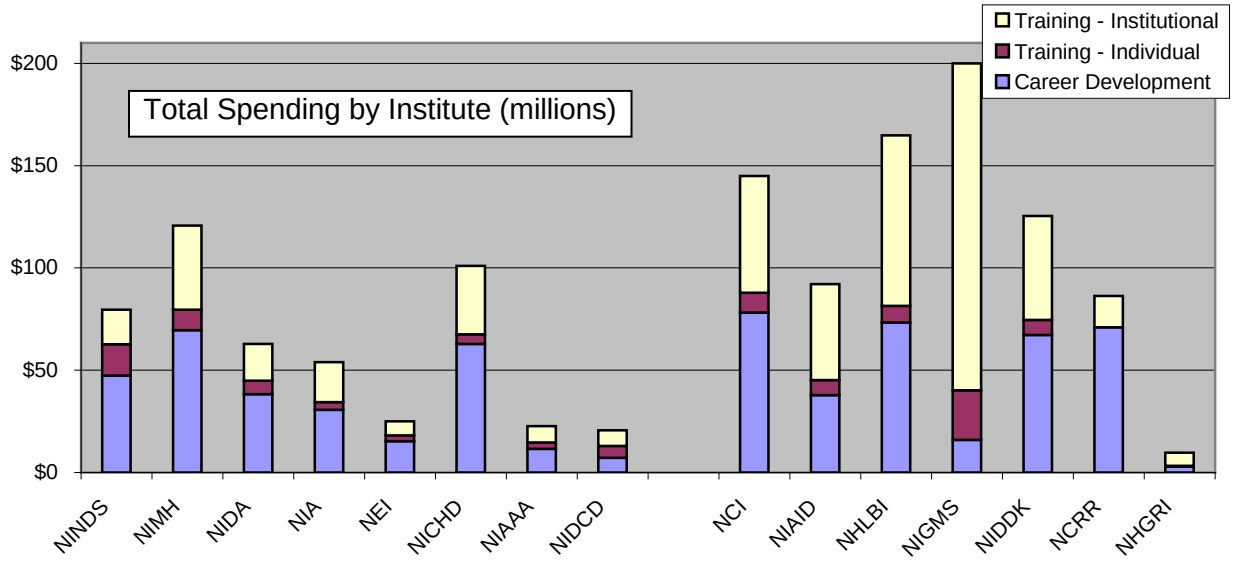
- **R25 - Research Education Grants** - NINDS offers support for a few scientific courses (10 courses in 2007, with an average award size of ~$80K), including courses at Marine Biological Laboratory and Cold Spring Harbor Labs, and has specific program announcements in Diversity Research Education and Global Health.
- **R13 and U13 - Conference Grants** - These support recipient-sponsored scientific meetings and conferences. The awards are typically small (~$5-15K) although larger amounts are awarded in some cases. Funding for Conference Grants was ~$900K in 2007. In addition, NINDS regularly sponsors workshops in areas deemed especially important for the Institute.

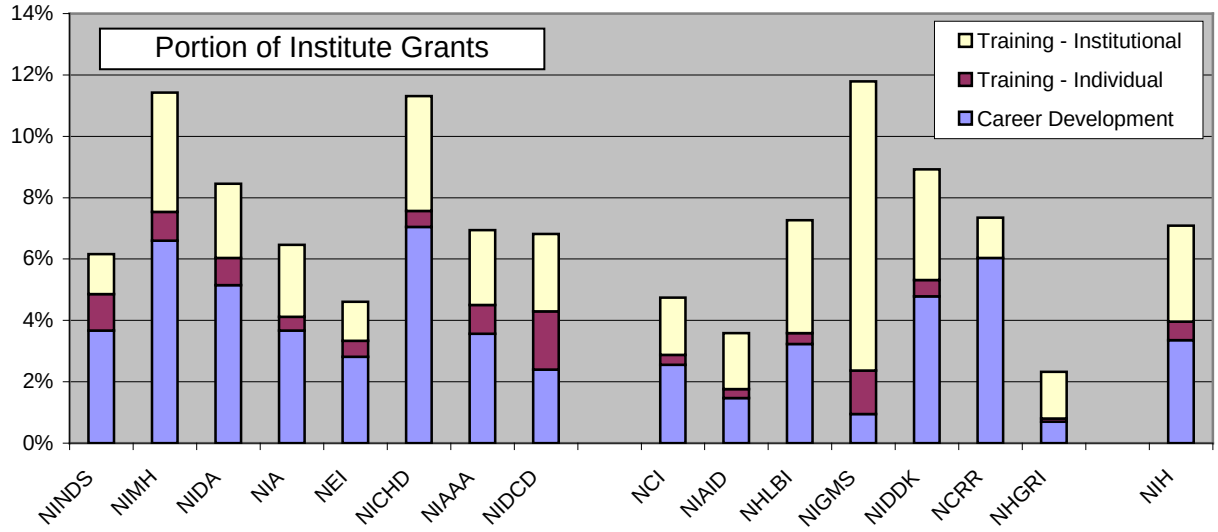
## B. NINDS Spending and Number of Trainees by Mechanism (FY07)

| Mechanism | Number of Trainees | Spending |
|---|---|---|
| ***Individual Fellowships*** | | |
| F30 | 79 | $2,916,929 |
| F31 | 224 | $7,010,239 |
| F32 | 118 | $5,493,539 |
| Subtotal | 421 | $15,420,707 |
| ***Training Programs (NINDS T32 + Joint T32)*** | | |
| T32* | 335 | $16,765,381 |
| ***Career Development Awards*** | | |
| K01 | 24 | $3,565,007 |
| K02 | 39 | $5,721,696 |
| K08 | 113 | $18,522,042 |
| K12 | 9 | $3,245,909 |
| K23 | 73 | $11,802,813 |
| K24 | 10 | $1,417,859 |
| K25 | 10 | $1,472,532 |
| K99 | 13 | $1,103,536 |
| Subtotal | 291 | $46,851,394 |
| **Grand Total** | **1047** | **$79,037,482** |

***The number of trainees for the T32 Programs was estimated based on ~$50,000 per trainee.

## C. Training Spending by NIH Institute



## D. Grants Funded by the NINDS T32 Program in FY08

| Institution | Title | Trainees | Major Focus |
|---|---|---|---|
| Baylor College of Medicine | Developmental Neurology and Clinical Neurophysiology | | |
| Baylor College of Medicine | Multidisciplinary Training in Brain Disorders and Development | MD | brain disorders and development - neurodevelopmental disorders |
| Brandeis University | Neurobiology: Genes, Channels, and Behavior | MD, PHD, MD/PHD (post) | broadly based interdisciplinary |
| Brown University | Neuroscience Advanced Predoctoral Institutional Training Grant | PhD | broad |
| California Institute of Technology | Molecular, Cellular and Systems Neuroscience | PHD, MD (post) | broad |
| Children's Hospital Boston | Developmental Neurology | PHD, MD, MD/PHD (post) | developmental neurology |
| Children's Hospital of Philadelphia | Training Grant in Neurodevelopmental Disabilities | MD, PHD (post) | neurodevelopmental disabilities |
| Colorado State University-Fort Collins | Training in Synaptic Neurobiology | MD, PHD, DVM (pre, post) | synaptic neurobiology |
| Columbia University Health Sciences | Neuroepidemiology Training Program | MD/DO, PHD (post) | neuroepidemiology |
| Columbia University Health Sciences | Clinical Neuroscience Training Program | MD, MD/PhD (post) | clinical research |
| Dartmouth College | Translational Neuroscience Postdoctoral Training Program | | |
| Drexel University | Biological Bases of Nervous Systems Disorders | MD, PHD (post) | cellular / developmental, systems / behavioral, spinal cord / regeneration, neuroengineering |
| Duke University | Training in Fundamental & Translational Neuroscience | MD, PHD | broad |
| Emory University | Training in Translational Research in Neurology | MD, PHD, MD/PHD (pre, post) | translational research in neurology |
| Georgetown University | Training in Neural Injury and Plasticity | PHD (pre,post) | CNS injury/repair, clinical exposure for PHDs |
| Harvard University (Medical School) | Fundamental Neurobiology | PhD, MD, MD/PHD (post) | fundamental neuroscience |
| Harvard University (Sch of Public Hlth) | Training in Neurostatistics and Neuroepidemiology | PHD (pre, post) | biostatistics and neuroepidemiology |
| Jackson Laboratory | Training in Mouse Neurogenetics | PHD (post) | mouse neurogenetics |
| Mayo Clinic Coll of Medicine, Rochester | Research Training Program in Neuro-Oncology | MD, PHD, MD/PHD (post) | brain tumors |
| Medical College of Georgia (Mcg) | Neurodegenerative diseases and neural repair | PHD, MD/PHD (pre, post) | neurodegeneration |
| Medical University of South Carolina | Biostatistics Training with Application to Neuroscience | PHD (pre) | biostatistics |
| Mount Sinai School of Medicine of NYU | Cerebrovascular Research Training Program | MD, PHD (post) | cerebrovascular disease - integrates MDs and PHDs |
| Northwestern University | Training Program in the Neuroscience of Human Cognition | PHD (pre,post) | human cognition |

| Institution | Title | Trainees | Major Focus |
|---|---|---|---|
| Northwestern University | General Motor Control Mechanisms and Disease Training Program | PHD (pre,post) | somatic and autonomic control |
| Oregon Health & Science University | Training Program in Neurological Sciences | MD, PHD (post) | broad |
| Oregon Health & Science University | Training Program in Neuronal Signaling | PHD,MD (post) | basic |
| Scripps Research Institute | Virology of the Central Nervous System | MD, PHD, DVM (post) | neurovirology |
| Stanford University | Epilepsy Training Program | | |
| Univ of Med/Dent of NJ-NJ Medical School | Training for Integrative Neuroscience in Health and Disease | PHD (pre,post) | broad |
| University of Alabama At Birmingham | Training Program in Brain Tumor Biology | MD,PHD (pre,post) | brain tumor biology |
| University of Alabama At Birmingham | UAB Pre and Post-Doctoral Training Program in Biostatistics | PHD (pre,post) | biostatistics |
| University of Alabama At Birmingham | Training Program in the Neurobiology of Cognition and Cognitive Disorders | PhD, MD/PhD | Cognition and Cognitive Disorders |
| University of California Irvine | Epilepsy Research Training Program | MD, PHD (post) | epilepsy |
| University of California Los Angeles | Training Program in Neural Repair | MD, PHD (pre, post) | neural repair |
| University of California Los Angeles | Training Program in Neural Microcircuits | PHD (pre,post) | cellular/circuits |
| University of California Los Angeles | Training Grant in Neurobehavioral Genetics | PHD, MD, MD/PHD (post) | Neurobehavioral Genetics |
| University of California Los Angeles | Cellular Neurobiology | PHD, MD (post) | cellular/molecular |
| University of California San Diego | Neurobiology Training Grant | PHD (post) | broad, interdisciplinary |
| University of Cincinnati | Cerebrovascular Fellowship Training Program | MD, MD/PhD | cerebrovascular disease |
| University of Cincinnati | Predoctoral Training Program in the Neurosciences | | |
| University of Colorado Denver | Neurovirology-Molecular Biology | MD, PHD (pre, post) | virology and molecular biology |
| University of Colorado Denver | Advanced Training in Basic Neuroscience | PHD (per, post) | broad basic |
| University of Florida | Integrative and translational training in pain research | PhD, MD, MD/PHD (post) | pain |
| University of Iowa | Interdisciplinary Training Program in Pain Research | PHD, MD, MD/PHD (pre, post) | pain |
| University of Maryland Baltimore | Training Program in Cellular & Integrative Neuroscience | MD, PHD, MD/PHD (post) | cellular and integrative neuroscience |
| University of Miami School of Medicine | TRAINING PROGRAM IN CNS INJURY AND REPAIR | MD, PHD (pre, post) | CNS injury and repair |
| University of Miami School of Medicine | Synapses,Channels, and Transduction in Neuroscience | MD, PHD (pre, post) | cellular/molecular |
| University of Michigan At Ann Arbor | Training in Clinical and Basic Neuroscience | PHD,MD (post) | integration of clinical and basic training |
| University of Pennsylvania | Neurologic Clinical Epidemiology Training Program | MD or MD/PhD | clinical epidemiology |
| University of Pennsylvania | Neuroscience neuroimaging training program | MD, PHD (pre,post) | neuroimaging |
| University of Pennsylvania | TRAINING IN NEUROVIROLOGY | MD, PHD (pre, post) | neurovirology |

| Institution | Title | Trainees | Major Focus |
|---|---|---|---|
| University of Pennsylvania | Brain injury training grant | MD, PHD (post) | CNS injury |
| University of Pittsburgh At Pittsburgh | Training in the Neurobiology of Neurodegenerative Disease | PHD, MD/PHD, MD? (post) | neurodegeneration: basic and translational |
| University of Rochester | Experimental Therapeutics in Neurological Disease | MD, MD/PhD (post) | clinical research/trials in neurological disease |
| University of Rochester | Training in Neuroinflammation and Glial Cell Biology | PHD, MD/PHD (pre, post) | neuroinflammation and glial studies |
| University of Texas Hlth Sci Ctr Houston | The University of Texas Houston Stroke Training Program | MD, MD/PhD (post) | cerebrovascular |
| University of Washington | Training in Molecular Neurobiology | PHD (post) | cellular, molecular neuroscience |
| University of Washington | Clinical Neurosciences Training | PHD, MD (pre,post) | integration of clinical and basic training |
| University of Washington | Research Training in Neurology | MD (post) | neurology research - 65% of graduates have academic/research positions |
| Vanderbilt University | Alliance for Research Training in Neuroscience | PHD (pre, post) | Part of a Diversity RFA - to promote diversity in neuroscience |
| Vanderbilt University | Training Program in Ion Channel and Transporter Biology | MD, PHD (pre, post) | channels and transporters |
| Virginia Commonwealth University | The Brain Parenchymal and Vascular Response to Trauma | MD, PHD, MD/PHD | CNS injury/repair - integrates MD and PHD |
| Wake Forest University Health Sciences | NIH Predoctoral Training Program in Neuroscience | | |
| Washington University | Nervous System Development and Injury | MD,MD/PHD | neurodevelopment, CNS injury/repair |
| Yale University | Neurobiology of cortical Systems. | MD, PHD, MD/PHD (pre, post) | development, organization, and plasticity of the mammalian brain |
| Yale University | Neuropharmacology Training Program | MD, PHD (pre, post) | neuropharmacology |
| Yeshiva University | Mechanisms of Intercellular Communication | MD, PHD, MD/PHD (post) | intercellular communication |
| Yeshiva University | Molecular Neuropathology | PHD, MD (pre,post) | disease-oriented molecular neuroscience |

## E. Trainees Supported through the Jointly T32 Program by IC

Below, we list the historical support of each participating IC in terms of number of slots supported.

| IC | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NINDS** | 39 | 30 | 63 | 70 | 101 | 109 | 101 | 104 | 88 | 82 | 79 | 69 |
| **NIMH** | 19 | 30 | 46 | 47 | 58 | 57 | 55 | 46 | 49 | 49 | 53 | 56 |
| **NIDA** | | | | | | 1 | 2 | 5 | 11 | 8 | 8 | 8 |
| **NIA** | 6 | 6 | 11 | 11 | 17 | 14 | 14 | 15 | 15 | 14 | 14 | 14 |
| **NEI** | | | | 2 | 2 | 8 | 8 | 7 | 17 | 23 | 25 | 22 |
| **NICHD** | | 6 | 6 | 6 | 10 | 10 | 10 | 12 | 10 | 10 | 12 | 12 |
| **NIDCD** | | 1 | | 3 | 8 | 8 | 8 | 8 | 2 | 6 | 6 | 6 |
| **NIDCR** | | 7 | 7 | 13 | 13 | 6 | 6 | 6 | 3 | | | |
| **NIAAA** | | | | | | | | | | 1 | 1 | 2 |
| **NIGMS** | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 9 |
| **NINR** | | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Totals** | **70** | **88** | **141** | **160** | **217** | **220** | **212** | **211** | **203** | **201** | **206** | **200** |