Impact of the *Xenopus* system on the missions of the NIGMS

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The NIGMS "supports basic research that increases understanding of life processes and lays the foundation for advances in disease diagnosis, treatment, and prevention" (http://www.nigms.nih.gov/Initiatives/). Experiments in model animals are a cornerstone of such fundamental biomedical research and they play a particularly important role in the mission of the NIGMS.

The frog, *Xenopus,* is a widely used and crucial vertebrate model organism that is unique for its combination of its experimental tractability and its close evolutionary relationship with humans. *Xenopus* is an essential tool for *in vivo* studies in molecular, cell, and developmental biology of vertebrate animals. However, the enormous breadth of *Xenopus* research stems from the additional fact that cell-free extracts made from *Xenopus* are a premier *in vitro* system for studies of fundamental aspects of cell and molecular biology. Thus, *Xenopus* is the only vertebrate model system that allows for high-throughput *in vivo* analyses of gene function and high-throughput biochemistry. Finally, it should be borne in mind that *Xenopus* oocytes are a leading system for studies of ion transport and channel physiology.

Because of its diverse applications, *Xenopus* research is funded by nearly all Institutes within the NIH. However, the NIGMS remains by far the largest source of funding for *Xenopus* research. In this statement, we provide a summary of the crucial contributions made by *Xenopus* research to the mission of the NIGMS. We start with recent contributions of *Xenopus* to the study of known human disease genes. We follow this with a selection of examples that illustrate the huge impact that recent *Xenopus* research has had on our understanding of fundamental biological processes. Finally, we summarize very briefly the long and rich history which formed the foundation for myriad current advances being made *Xenopus* research to our understanding of the biology underlying human disease.

I. Direct investigation of human disease genes using *Xenopus*:

The NIGMS funds research that "lays the foundation for advances in disease diagnosis, treatment, and prevention" (http://www.nigms.nih.gov/Initiatives/). Therefore, it is notably that all modes of *Xenopus* research (embryos, cell-free, extracts, and oocytes) are now commonly and widely used in direct study of human disease genes.

Xenopus embryos for in vivo studies of human disease gene function: *Xenopus* embryos are large and easily manipulated, and moreover, many hundreds of embryos can be obtained in a single day. It is not surprising, then, that *Xenopus* was the first vertebrate animal for which methods were developed that allowed rapid analysis of gene function using misexpression (by mRNA injection; *Nature.* 1971. 233, 177-82). Indeed, injection of mRNA in *Xenopus* led to the cloning of interferon (*PNAS.* 1975. 72, 4881-4885). Moreover, the use of morpholino-antisense oligonucleotides for gene knockdowns in vertebrates, which is now the state-of-the-art, was first developed by Janet Heasman using *Xenopus* (*Dev. Biol.* 2000. 222, 124-34.).

In recent years these approaches have played in important role in studies of human disease genes. The mechanism of action for several genes mutated in human cystic kidney disorders (e.g. nephronophthisis) have been extensively studied in *Xenopus* embryos, shedding new light on the link between these disorders, ciliogenesis and Wnt signaling (*Hum Mol Genet.*

2008. 17, 3655-62). *Xenopus* embryos have also provided a rapid test bed for validating newly-discovered disease genes. For example, studies in *Xenopus* confirmed and elucidated the role PYCR1 in cutis laxa with progeroid features **(***Nat Genet.* 2009. 41, 1016-21).

Transgenic Xenopus for studying transcriptional regulation of human disease genes: *Xenopus* embryos develop rapidly, and so transgenesis in *Xenopus* is a rapid and effective method for analyzing genomic regulatory sequences. In a recent study, mutations in the SMAD7 locus were revealed to associate with human colorectal cancer. Interestingly, the mutations lay in conserved, but non-coding sequences, suggesting that these mutations impacted the patterns of SMAD7 transcription. To test this hypothesis, the authors used *Xenopus* transgenics, and revealed that this genomic region drove expression of GFP in the hindgut. Moreover, transgenics made with the mutant version of this region displayed substantially less expression in the hindgut (*Genome Res.* 2009. 19, 987-93.).

Xenopus cell-free extracts for biochemical studies of proteins encoded by human disease genes: A unique advantage of the *Xenopus* system is that cytosolic extracts contain both soluble cytoplasmic and nuclear proteins (including chromatin proteins). This is in contrast to cellular extracts prepared from somatic cells with already distinct cellular compartments. *Xenopus* egg extracts have provided innumerable insights into the basic biology of cells with particular impact on cell division and the DNA transactions associated with it.

Studies in *Xenopus* egg extracts have also yielded critical insights into the mechanism of action of human disease genes associated with genetic instability and elevated cancer risk, such as ATM (Ataxia telangiectasia), BRCA1 (Inherited Breast and Ovarian cancer), Nbs1 (Nijmegen Breakage Syndrome), RecQL4 (Rothmund-Thomson Syndrome), c-Myc oncogene and FANC proteins (Fanconi anemia) (*Cell.* 2006, 127, 539-52; *Nat. Cell Biol*. 2007. 9, 1311-18; *Mol. Cell.* 2009. 35, 704-15; *J Biol Chem.* 2009, 284, 25560-8; *Nature*. 2007. 448, 445-51).

Xenopus oocytes for studies of gene expression and channel activity related to human disease: Yet another strength of *Xenopus*, and another strength that is simply not matched by any other vertebrate model system, is the ability to rapidly and easily assay the activity of channel and transporter proteins using expression in oocytes. This application has also led to important insights into human disease, including studies related to trypanosome transmission (*Nature* 2009. 459, 213-217), Epilepsy with ataxia and sensorineural deafness (*N Engl J Med.* 360, 1960-70), Catastrophic cardiac arrhythmia (Long-QT syndrome; *PNAS* 2009. 106,13082-7) and Megalencephalic leukoencephalopathy (*Hum Mol Genet.* 2008. 17, 3728-39).

II. Investigation of fundamental biological processes using *Xenopus*:

In addition to applied studies directed at the mechanisms of known human disease genes, the NIGMS very broadly supports “basic research that increases understanding of life processes” (http://www.nigms.nih.gov/Initiatives/). It is this area where *Xenopus* has made its most substantive and wide-ranging contributions.

To name only a few areas of study in which *Xenopus* has had a large impact in the last two years:

Signal transduction: *Xenopus* embryos and cell-free extracts are widely used for basic research in signal transduction. In just the last few years, *Xenopus* embryos have provided crucial insights into the mechanisms of TGF-® and Wnt signal transduction. For example, *Xenopus* embryos were used to identify the enzymes that control ubiquitination of smad-4 (*Cell*. 2009. 136,123-35), and also to demonstrate direct links between TGF-® superfamily signaling pathways and other important networks, such as the MAP kinase pathway (*Science*. 2007. 315,

840-3) and the Wnt pathway (*Cell*. 2007. 131, 980-993). Moreover, new methods using egg extracts revealed novel, important targets of the Wnt/GSK3 destruction complex (*PNAS*. 2009. 106, 5165-5170).

Cell division: *Xenopus* egg extracts have allowed the study of many complicated cellular events in a test tube. Because egg cytosol can support successive cycling between mitosis and interphase *in vitro*, it has been critical to diverse studies of cell division. For example, the small GTPase Ran was first found to regulate interphase nuclear transport, but *Xenopus* egg extracts revealed the critical role of Ran GTPase in mitosis independent of its role in interphase nuclear transport (*Nature*. 2006 440, 697-701). Similarly, the cell-free extracts were used to model nuclear envelope assembly from chromatin, revealing the function of RanGTPase in regulating nuclear envelope reassembly after mitosis (*Science* 2006 311, 1887-1893). More recently, using *Xenopus* egg extracts, it was possible to demonstrate the mitosis-specific function of the nuclear lamin B in regulating spindle morphogenesis (*Nat. Cell Biol.* 2009. 11, 247-256) and to identify new proteins that mediate kinetochore attachment to microtubules (*Cell*. 2007. 130, 893-905.

Embryonic development: *Xenopus* embryos are so widely used in developmental biology that it is impossible to quickly summarize the myriad of important advances made by *Xenopus* research in recent years. A very short list would include:

- Epigenetics of cell fate specification (*Dev. Cell.* 2009. 17, 425-434),
- microRNAs in germ layer patterning and eye development (*Dev. Cell.* 2009. 16, 517-527*; Genes & Dev.* 2009. 23, 1046-1051)
- Link between Wnt signaling and telomerase (*Nature*. 2009. 460, 66-72),
- Development of the vasculature (*Cell*. 2008.135, 1053-64),
- Gut morphogenesis (*Genes & Dev.* 2008. 22, 3050-3063),
- Contact inhibition and neural crest cell migration (*Nature*. 2008. 146, 957-961).

Initiation of DNA replication: *Xenopus* cell-free extracts also support the synchronous assembly and the activation of origins of DNA replication. They have been instrumental in characterizing the biochemical function of the pre-replicative complex, including MCM proteins (*Mol. Cell*. 2008. 32, 862-9; *EMBO J.* 2009. 28, 3005-14).

Response to DNA damage: Cell-free extracts have been instrumental to unravel the signaling pathways that are activated in response to DNA double-strand breaks (ATM), replication fork stalling (ATR) or DNA interstrand crosslinks (FA proteins and ATR). Notably, several mechanisms and components of these signal transduction pathways were first identified in *Xenopus* (*Mol Cell.* 2009. 35,704-15; *Cell.* 2008. 134, 969-80; *Genes Dev.* 2007. 21, 898-903).

Apoptosis: *Xenopus* oocytes provide a tractable model for biochemical studies of apoptosis. Recently, oocytes were used recently to study the biochemical mechanisms of caspase-2 activation; importantly, this mechanism turns out to be conserved in mammals (*Dev Cell.* 2009. 16, 856-66).

Regenerative medicine: In recent years, there has been tremendous interest in developmental biology stoked by the promise of regenerative medicine. *Xenopus* has played a role here as well. For example, it has been found that expression of seven transcription factors in pluripotent *Xenopus* cells rendered those cells able to develop into functional eyes when implanted into *Xenopus* embryos, providing potential insights into the repair of retinal

degeneration or damage (*PLoS Biology*. 2009. 7, e1000174.).

In a vastly different study, *Xenopus* embryos was used to study the effects of tissue tension on morphogenesis (*Dev Cell.* 2009. 16, 421-432.), an issue that will be critical for *in vitro* tissue engineering.

Physiology: The directional beating of multi-ciliated cells is essential to development and homeostasis in the central nervous system, the airway, and the oviduct. Interestingly, the multi-ciliated cells of the *Xenopus* epidermis have recently been developed as the first *in vivo* test-bed for live-cell studies of such ciliated tissues, and these studies have provided important insights into the biomechanical and molecular control of directional beating (*Nat Genet.* 2008. 40, 871-9; *Nature*. 2007. 447, 97-101).

III. Use of *Xenopus* for small molecule screens to develop novel therapeutics.

Because huge amounts of material are easily obtained, all modalities of *Xenopus* research are now being used for small-molecule based screens.

Chemical genetics of vascular growth in Xenopus tadpoles: Given the important role of neovascularization in cancer progression, *Xenopus* embryos were recently used to identify new small molecules inhibitors of blood vessel growth. Notably, compounds identified in *Xenopus* were effective in mice (*Blood*. 2009. 114, 1110-22; *Blood*. 2008. 112, 1740-9).

In vivo testing of potential endocrine disruptors in transgenic Xenopus embryos: Endocrine disrupting chemical released into the environment are pose a potential public health risk, but our ability to identify such compounds in vitro vastly outstrips our ability to monitor the in vivo effects of such chemicals. A high-throughput assay for thyroid disruption has recently been developed using transgenic *Xenopus* embryos (*Environ. Sci. Technol.* 2007. 41, 5908-14).

Small molecule screens in Xenopus egg extracts: Egg extracts provide ready analysis of molecular biological processes and can rapidly screened. This approach was used to identify novel inhibitors of proteasome-mediated protein degradation and DNA repair enzymes (*Nat Chem Biol.* 2008. 4, 119-25; *Int. J. Cancer*. 2009. 124, 783-92).

IV. A long history of research laid the foundation for the myriad recent contributions of *Xenopus* to biomedical science.

In addition to its current wide usage in diverse areas of biology, we feel that it is also worth summarizing the some of the landmark discoveries that come to mind when thinking about the contributions of *Xenopus* to the NIH.

1950's

- The discovery that somatic nuclei are totipotential, from which present excitement about nuclear reprogramming and stem cells arises (Gurdon et al., 1958).

1960's

- 1969: The discovery that the nucleolar organizer encodes the ribosomal RNA genes (Brown and Gurdon, 1969).
- 1968: Selective DNA amplification of rDNA in oogenesis (Brown and Dawid, 1968; Gall, 1968).
- Mitochondrial DNA exists and is inherited from the mother (Dawid, 1966).

1970's

- The isolation of the first eukaryotic genes by equilibrium density centrifugation in the form of rRNA and 5S genes (Birnstiel et al., 1968; Brown et al., 1971).
- The first eukaryotic translation system by oocyte mRNA microinjection (Gurdon et al., 1971).
- The first transcription and translation system for cloned genes (Brown and Gurdon, 1977; De Robertis and Mertz, 1977).
- Discovery of MPF, a meiosis maturation promoting factor that provided the key to the elucidation of the cell cycle (Wasserman and Masui, 1976).
- First system for electrophysiological studies on cloned membrane channels and receptors (Kusano et al., 1977).
- Identification of nuclear targeting signal sequences in the mature sequence of nuclear proteins (De Robertis et al., 1978).

1980's

- The isolation of the first eukaryotic transcription factor, TFIIIA (Engelke et al., 1980).
- First in vitro system for nuclear and chromosome assembly (Lohka and Masui, 1983).
- Discovery of the first Hox gene homologue in vertebrates (Carrasco et al., 1984).
- Mesoderm induction is mediated by members of the TGF-beta family of growth factors (Smith, 1987).
- Cell cycle progression is regulated through protein degradation of cyclins via ubiquitinylation (Murray et al., 1989).

1990's

- Realization that Homeobox genes direct gastrulation morphogenetic movements (Niehrs et al., 1993).
- Molecular nature of Spemann's organizer: cell-cell signals are regulated by secreted growth factors antagonists such as Noggin, Gremlin, Follistatin, Chordin, Cerberus, Frzb and Dickkopf (reviewed by Harland and Gerhart, 1997).
- Identification of the cell-cell signals that cause induction and patterning of the Central Nervous System (Zimmerman et al., 1996; Piccolo et al., 1996).

These and many other past discoveries would more than justify a re-dedication of the NIGMS's efforts to the acceleration and promotion of biomedical research using *Xenopus*. But as the document above makes clear, the current, sustained contributions made by this system are such that *Xenopus* should be considered one of the most promising post-genomic systems for research in Cell and Molecular Biology.

Xenopus Grants funding by the NIGMS

According to NIH RePORTER Search Tool, in the fiscal year of 2009, the National Institute of General Medical Sciences (NIGMS) **funded 152 grants** for projects involving *Xenopus*. These grants total **$43,883,452**. See appendix for a complete list.

2009 *Xenopus* White Paper – Community Needs

Executive Summary

Xenopus - a crucial model organism for biomedical research:

Experiments in model animals are a cornerstone of biomedical research and have a massive impact on our understanding of human health and disease. The frog, *Xenopus,* is a widely used and crucial vertebrate model organism that offers a unique combination of three powerful advantages: strong conservation of essential biological mechanisms, a remarkable experimental repertoire, and unparalleled cost-effectiveness when compared to murine or other mammalian models.

In fact, for many experimental applications, *Xenopus* is the only viable model system. For example, in cell and molecular biology, *Xenopus* extracts allow for individual components of the cell cycle or DNA replication/repair machinery to be analyzed in a manner that cannot be recapitulated *in vivo* or in cell culture. For developmental biology, no other model system allows for high-throughput genomic/proteomic screening and at the same time allows for transplant/explant analysis (i.e. "experimental embryology"). The *Xenopus* oocyte is unique as a system for studying channel physiology using the patch-clamp and as a system for protein expression. Finally, *Xenopus* is the only vertebrate model that readily produces enough biological material for biochemical purification from eggs, intact embryos, or isolated embryonic tissues. The combination of these characteristics offers a wide range of experimental opportunities for studies using the *Xenopus* system in contrast to other vertebrates such as the mouse or zebrafish.

NIH Investment in *Xenopus:*

The NIH has made a substantial and continuing investment in *Xenopus* research. Indeed, a search of the NIH rePORT database for R01's or equivalent grants using the search term "*Xenopus*" returned **427 grants for a total cost of $127,583,776** for FY08 and FY09. Despite this investment in individuals' research, the *Xenopus* community lacks many resources that are considered entirely essential for other model systems, including a complete genome sequence, stock and training centers, and a comprehensive model organism database.

Xenopus as a Model System and Human Disease:

Given the tremendous advantages of the *Xenopus* system, the pace of new biological discovery by the *Xenopus* Community is brisk. Using *Xenopus*, we have significantly improved our understanding of human disease genes and their mechanisms, justifying the NIH's investment in *Xenopus*. Below we provide examples of just a few of the human health discoveries made in the last two years:

Xenopus embryos are used for *in vivo* analysis of gene expression and function:

Nephronophthisis - *Hum Mol Genet.* 2008. 17, 3655-62; *Nat Genet. 2005*. 37, 537-43.
Cutis laxa - *Nat Genet.* 2009. 41, 1016-21.
Meckel-Gruber syndrome - *Am J Hum Genet.* 2008. 82, 959-70.
Colorectal cancer - *Genome Res.* 2009. 19, 987-93.

Xenopus egg extracts are used for *in vitro* biochemical studies:

Fanconi Anemia - *Mol. Cell.* 2009. 35, 704-15; *J Biol Chem.* 2009, 284, 25560-8.
C-myc oncogene - *Nature*. 2007. 448, 445-51.
BRCA1 - *Cell*. 2006. 127, 539-552

Xenopus oocytes are used to study gene expression and channel activity:

Trypanosome transmission - *Nature* 2009. 459, 213-217.
Epilepsy, ataxia, sensorineural deafness - *N Engl J Med.* 360, 1960-70.
Catastrophic cardiac arrhythmia (Long-QT syndrome) - *PNAS* 2009. 106,13082-7.
Megalencephalic leukoencephalopathy - *Hum Mol Genet.* 2008. 17, 3728-39.

Xenopus as a Model System and Basic Biological Processes:

Xenopus also plays a crucial role in elucidating the basic cellular and biochemical mechanisms underlying the entire spectrum of human pathologies. Again only a few of the many discoveries in the last two years are highlighted here:

Xenopus embryos were used for studies of TGF-® signal transduction.
(*Cell*. 2009. 136,123-35; *Science*. 2007. 315, 840-3).

Xenopus egg extracts revealed fundamental aspects of cell division.
(*Nature*. 2008. 453, 1132-6; *Science*. 2008. 319, 469-72).

Xenopus embryos were used for studying mucociliary epithelia.
(*Nat Genet.* 2008. 40, 871-9; *Nature*. 2007. 447, 97-101).

Xenopus embryos were used for studying development of the vasculature.
(*Cell*. 2008.135, 1053-64).

Xenopus egg extracts provided key insight into DNA damage responses.
(*Mol Cell.* 2009. 35,704-15; *Cell.* 2008. 134, 969-80).

Xenopus embryos linked telomerase to Wnt signaling.
(*Nature*. 2009. 460, 66-72).

Xenopus was used for small molecule screens to develop therapeutics.
(Nat Chem Biol. 2008. 4, 119-25; Blood. 2009. 114, 1110-22).

Immediate Needs of the *Xenopus* Community:

It is the consensus of the *Xenopus* community that their biomedical research could be greatly accelerated by the development of key resources that are currently lacking. These resources would be of use to the entire *Xenopus* research community. In this White Paper, the community identifies seven resources in two categories: Three Immediate Needs and four Essential Resources:

The **Immediate Needs** are a common set of key resources that were identified as the most pressing by three committees established to identify needed resources across the broad and diverse *Xenopus* community. There is a broad, community-wide consensus that these resources would have an immediate impact on all *Xenopus* users and should be assigned the highest priority in order to accelerate the pace of biomedical research using *Xenopus* as a model system.

These Immediate Needs and the resulting improvements in biomedical research are as follows:

1. *Establishment of the Xenopus Resource and Training Center at the MBL in Woods Hole.*
   -Will allow rapid distribution of transgenic *Xenopus laevis* lines expressing fluorescent reporters and tagged proteins (for example histone-RFP for visualizing the mitotic spindle or organ specific GFP in embryos)
   -Will allow centralized generation, housing, and distribution of genetically modified *X. tropicalis* lines, including both mutants and transgenics.
   -Will allow both current investigators and the next generation of researchers to get hands-on training in *Xenopus*-based biomedical research methods (including cell, molecular, and developmental methods).
2. *Expansion and improvement of Xenbase, a Xenopus model organism database.*
   -Maintain and curate data for the essential primary database for *Xenopus* researchers.

-Enhance the functionality of *Xenbase* by introducing a phenotypes feature.
-Support new content on *Xenbase*, including proteomics support, a new genome browser, and Wiki for *Xenopus* methods.
-Continue and expand collaborative and service efforts (e.g. provide *Xenopus* data to other databases including NCBI, UniProtK, Mascot and Tornado).

3. *Complete sequencing of the Xenopus laevis genome.*
-Will allow the deconvolution of data in mass-spectrometry-based proteomic studies.
-Will facilitate identification of conserved gene regulatory regions to build gene-regulatory networks.
-Will facilitate site-specifc studies of DNA transaction (repair and replication)
-Will facilitate identification of all ORFs to build an ORFeome for rapid functional characterization of genes
-Will facilitate the design of morpholino oligonucleotides for gene depletion studies
-Will faciliate the analysis of chromatin-immunoprecipitations to identify DNA-bound to transcription factors and DNA modifications.

Essential Resources Needed by the *Xenopus* Community:

In addition to these immediate, community-wide needs, the committees identified four **Essential Resources** that should be developed as soon as possible, so that *Xenopus* biologists can more effectively fulfill the missions of the NIH. The *Xenopus* community considers all four of these additional resources to be essential, but understands that priorities must be set, and ranks these behind the Immediate Needs. These Essential Resources are as follows:

4. *Xenopus ORFeome in recombineering vectors.*
5. *Improvement of the X. tropicalis genome sequence and annotation*
6. *Development of methods for disrupting gene function in Xenopus.*
7. *Generation and Distribution of antibodies for Xenopus research.*

Anticipated Gains for Biomedical Research:

Xenopus is a crucial model organism for biomedical research. With the development of large-scale community-wide resources, *Xenopus* is poised to be become the premier vertebrate model for systems-level approaches to understanding biological mechanisms in cell, molecular, and developmental biology.

The National Research Council and the National Academy of Sciences have recently called on the Unites States “to launch a new multiagency, multiyear, and multidisciplinary initiative to capitalize on the extraordinary advances recently made in biology”. This report (http://www.nap.edu/catalog.php?record_id=12764) recommends the term "new biology" to describe an approach to research where “physicists, chemists, computer scientists, engineers, mathematicians, and other scientists are integrated into the field of biology.” The promise of systems-level analysis in *Xenopus*, combined with its already proven strengths, make *Xenopus* the ideal model organism for pursuing this “new biology.”

Genome improvements will provide *Xenopus* researchers with the ability to perform genome-wide screens for biological activities that will in turn allow the rapid assembly and analysis of gene regulatory networks. The ORFeome will greatly facilitate such genome-wide screening by allowing all ORFs to be rapidly analyzed or large numbers of proteins to be tagged for analysis of protein-protein interaction or for *in vivo* visualization. Using extracts and biochemical purification coupled with mass-spectrometry and genomic sequence, protein interactomes can be rapidly identified and validated. Because *Xenopus* can be so easily manipulated and because vast amounts of biological material can be generated, cell-type specific interactomes can also be identified. Large-scale genetic screens will identify important novel genes in developmental pathways, especially given the relatively simple genome of *X. tropicalis* compared to zebrafish. Finally, the flexibility of both *Xenopus* extracts and embryos make this system ideal for chemical biology screens. Identifying these gene-regulatory networks, interactomes, and novel genes will be only the first steps, of course. The well-

established power of *Xenopus* for rapid analysis of gene function will then allow deeply mechanistic analyses to complement the systems-level approaches described above.

It is the combination of these characteristics that distinguishes *Xenopus* from other vertebrate model systems such as mouse and zebrafish and allows for a systems-level approach to understanding biological mechanisms. The tremendous promise of the *Xenopus* model cannot be realized, however, without the immediate development of community-wide research resources. This White Paper presents the needed resources, and we look to the NIH for guidance in how to best achieve these goals.

For complete details of the 2009 Xenopus White Paper, please visit
http://www.xenbase.org/community/xenopuswhitepaper.do

Appendix

Xenopus Grants funded by the NIGMS

Project Number	Activity	Project Title	Principal Investigator	Organization	Total
5K99GM084292-02	K99	MICROTUBULE POLYMERIZATION AND DEPOLYMERIZATION MECHANISMS BY CONSERVED PROTEINS	AL-BASSAM, JAWDAT MH	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$72,306
5R01GM084491-02	R01	ANALYSIS OF TYRAMINERGIC SIGNALING IN CAENORHABDITIS ELEGANS	ALKEMA, MARK	UNIV OF MASSACHUSETTS MED SCH WORCESTER	$327,667
5F31GM073576-05	F31	THE ROLE OF STU1 IN MITOTIC SPINDLE STABILITY	AMARO, IRENE A	CORNELL UNIVERSITY ITHACA	$36,429
5R01GM080278-03	R01	REGULATION AND FUNCTION OF PIASY MEDIATED MITOTIC SUMOYLATION IN VERTEBRATES	AZUMA, YOSHIAKI	UNIVERSITY OF KANSAS LAWRENCE	$247,326
3R01GM080278-03S1	R01	REGULATION AND FUNCTION OF PIASY MEDIATED MITOTIC SUMOYLATION IN VERTEBRATES	AZUMA, YOSHIAKI	UNIVERSITY OF KANSAS LAWRENCE	$125,244
5R01GM046889-16	R01	STRUCTURE/FUNCTION OF GAP JUNCTIONS	BARGIELLO, THADDEUS ANDREW	ALBERT EINSTEIN COL OF MED YESHIVA UNIV	$480,696
2R01GM030376-30	R01	THE ELECTROPHYSIOLOGICAL STUDIES OF VOLTAGE GATED CHANNELS	BEZANILLA, FRANCISCO J	UNIVERSITY OF CHICAGO	$490,032
3R01GM030376-30S1	R01	THE ELECTROPHYSIOLOGICAL STUDIES OF VOLTAGE GATED CHANNELS	BEZANILLA, FRANCISCO J	UNIVERSITY OF CHICAGO	$341,835
2R01GM044592-18A1	R01	MECHANISM AND REGULATION OF RECEPTOR-G PROTEIN SIGNALING	BLUMER, KENDALL JAY	WASHINGTON UNIVERSITY	$568,136
1P30GM092374-01	P30	REGENERATIVE BIOLOGY CENTER AT THE MBL	BORISY, GARY G	MARINE BIOLOGICAL LABORATORY	$401,250

5R01GM066977-08	R01	TGFB SIGNALING IN VERTEBRATE MESODERM INDUCTION	BRIVANLOU, ALI H	ROCKEFELLER UNIVERSITY	$311,788
1R01GM083970-01A1	R01	KINASE ACTIVATION IN THE DNA DAMAGE CHECKPOINTS	BURGERS, PETER M	WASHINGTON UNIVERSITY	$258,400
3R37GM030997-27S1	R37	GENETIC ANALYSIS OF NEMATODE CELL DIFFERENTIATION	CHALFIE, MARTIN	COLUMBIA UNIV NEW YORK MORNINGSIDE	$187,436
1R01GM083029-01A2	R01	ERBB SIGNALING IN VERTEBRATE MORPHOGENESIS	CHANG, CHENBEI	UNIVERSITY OF ALABAMA AT BIRMINGHAM	$304,633
3R01GM075018-04S1	R01	REGULATION OF CALL ADHESION IN XENOPUS	CHO, KEN W.Y.	UNIVERSITY OF CALIFORNIA IRVINE	$94,198
5R01GM078502-03	R01	STRUCTURE/FUNCTION ANALYSIS OF THE NA/BICARBONATE COTRANSPORTERS	CHOI, INYEONG	EMORY UNIVERSITY	$267,750
3R01GM078502-03S1	R01	STRUCTURE/FUNCTION ANALYSIS OF THE NA/BICARBONATE COTRANSPORTERS	CHOI, INYEONG	EMORY UNIVERSITY	$247,488
5R01GM029513-29	R01	MICROTUBULE REGULATION	CLEVELAND, DON W.	LUDWIG INSTITUTE FOR CANCER RESEARCH	$611,119
3R01GM029513-29S1	R01	MICROTUBULE REGULATION	CLEVELAND, DON W.	LUDWIG INSTITUTE FOR CANCER RESEARCH	$162,658
5K08GM083216-02	K08	VOLATILE ANESTHETIC REGULATION OF TASK TANDEM PORE POTASSIUM CHANNELS	COTTEN, JOSEPH F	MASSACHUSETTS GENERAL HOSPITAL	$130,928
3K08GM083216-02S1	K08	VOLATILE ANESTHETIC REGULATION OF TASK TANDEM PORE POTASSIUM CHANNELS	COTTEN, JOSEPH F	MASSACHUSETTS GENERAL HOSPITAL	$108,000
5R01GM074771-03	R01	KINASES IN ION COTRANSPORTER FUNCTION	DELPIRE, ERIC J	VANDERBILT UNIVERSITY	$332,056
5R01GM052302-14	R01	BIOGENESIS OF VOLTAGE-GATED K+ CHANNELS	DEUTSCH, CAROL J	UNIVERSITY OF PENNSYLVANIA	$758,729
5R01GM016317-41	R01	RNASES AND RNA METABOLISM IN BACTERIA	DEUTSCHER, MURRAY P	UNIVERSITY OF MIAMI SCHOOL OF MEDICINE	$476,558
5SC3GM081165-02	SC3	MOLECULAR MECHANISMS UNDERLYING XENOPUS SOMITOGENESIS	DOMINGO, CARMEN R.	SAN FRANCISCO STATE UNIVERSITY	$115,032

5R01GM085456-02	R01	DE-DIFFERENTIATING ADULT HUMAN FIBROBLASTS INTO STEM-LIKE CELLS USING CONDITIONS	DOMINKO, TANJA	WORCESTER POLYTECHNIC INSTITUTE	$293,402
3R01GM085456-02S2	R01	DE-DIFFERENTIATING ADULT HUMAN FIBROBLASTS INTO STEM-LIKE CELLS USING CONDITIONS	DOMINKO, TANJA	WORCESTER POLYTECHNIC INSTITUTE	$104,069
2R01GM070891-05	R01	ROLE OF ATR IN CELL CYCLE CHECKPOINTS	DUNPHY, WILLIAM G.	CALIFORNIA INSTITUTE OF TECHNOLOGY	$466,716
5R01GM080570-03	R01	STRUCTURAL MECHANISMS OF MCM10 IN DNA REPLICATION	EICHMAN, BRANDT F	VANDERBILT UNIVERSITY	$274,595
1SC1GM086344-01	SC1	MOLECULAR PHYSIOLOGY OF Y-AMINOBUTYRIC ACID TRANSPORTERS	ESKANDARI, SEPEHR	CALIFORNIA STATE POLY U POMONA	$319,500
3SC1GM086344-01S1	SC1	MOLECULAR PHYSIOLOGY OF Y-AMINOBUTYRIC ACID TRANSPORTERS	ESKANDARI, SEPEHR	CALIFORNIA STATE POLY U POMONA	$39,283
5R01GM046383-20	R01	REGULATORS OF CDC2/CDK1	FERRELL, JAMES E.	STANFORD UNIVERSITY	$324,848
5R01GM077544-04	R01	BISTABILITY AND BIOLOGICAL OSCILLATIONS	FERRELL, JAMES E.	STANFORD UNIVERSITY	$258,867
5R01GM075249-05	R01	ROLES OF CHROMOSOMAL FACTORS IN CHROMOSOME SEGREGATION	FUNABIKI, HIRONORI	ROCKEFELLER UNIVERSITY	$304,460
2R01GM033397-25	R01	THE ORGANIZATION OF ANIMAL CELL NUCLEI	GALL, JOSEPH G.	CARNEGIE INSTITUTION OF WASHINGTON, D.C.	$423,325
5R01GM067758-06	R01	MECHANISM OF RNA LOCALIZATION IN DROSOPHILA DEVELOPMENT	GAVIS, ELIZABETH R.	PRINCETON UNIVERSITY	$332,289
3R01GM067758-06S1	R01	MECHANISM OF RNA LOCALIZATION IN DROSOPHILA DEVELOPMENT	GAVIS, ELIZABETH R.	PRINCETON UNIVERSITY	$457,756
5R01GM052111-11	R01	REGULATION OF COORDINATION OF MOLECULAR MOTORS	GELFAND, VLADIMIR I	NORTHWESTERN UNIVERSITY	$469,742
3R01GM048430-16S1	R01	DROSOPHILA GENES AFFECTING CHROMOSOME	GOLDBERG, MICHAEL L	CORNELL UNIVERSITY ITHACA	$129,044

		SEGREGATION			
5R01GM083071-02	R01	MECHANISMS OF C. ELEGANS GASTRULATION	GOLDSTEIN, ROBERT P	UNIVERSITY OF NORTH CAROLINA CHAPEL HILL	$276,520
5R37GM037432-24	R37	CATENIN AND CADHERIN SIGNALING IN DEVELOPMENT AND CANCER	GUMBINER, BARRY M.	UNIVERSITY OF VIRGINIA CHARLOTTESVILLE	$535,210
5R01GM052717-14	R01	BIOCHEMISTRY AND REGULATION OF CADHERIN ACTIVITY	GUMBINER, BARRY M.	UNIVERSITY OF VIRGINIA CHARLOTTESVILLE	$373,676
3R01GM052717-14S1	R01	BIOCHEMISTRY AND REGULATION OF CADHERIN ACTIVITY	GUMBINER, BARRY M.	UNIVERSITY OF VIRGINIA CHARLOTTESVILLE	$234,053
5R01GM078172-03	R01	NON-CANOICAL WNT SIGNALING AND CELL MOTILITY	HABAS, RAYMOND	UNIV OF MED/DENT NJ-R W JOHNSON MED SCH	$263,334
5R01GM077336-03	R01	MOLECULAR CHARACTERIZATION OF HEPATIC ORGANIC ANION TRANSPORTING POLYPEPTIDES	HAGENBUCH, BRUNO	UNIVERSITY OF KANSAS MEDICAL CENTER	$320,550
2R01GM042341-23	R01	GENE EXPRESSION IN AMPHIBIAN DEVELOPMENT	HARLAND, RICHARD M.	UNIVERSITY OF CALIFORNIA BERKELEY	$363,392
1R01GM086321-01	R01	A HIGH QUALITY GENOME ASSEMBLY FOR XENOPUS TROPICALIS	HARLAND, RICHARD M. ;ROKHSAR, DANIEL ;	UNIVERSITY OF CALIFORNIA BERKELEY	$392,693
2R01GM070565-05	R01	SYSTEMATIC ANALYSIS OF PROTEOLYSIS PATHWAYS FOR CULLIN TARGETS	HARPER, JEFFREY WADE	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$321,869
3R01GM070565-05S1	R01	SYSTEMATIC ANALYSIS OF PROTEOLYSIS PATHWAYS FOR CULLIN TARGETS	HARPER, JEFFREY WADE	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$100,000
5F32GM082014-03	F32	MECHANISM OF PCNA-DEPENDENT CDT1 DESTRUCTION IN S PHASE	HAVENS, COURTNEY G	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$51,710
2R01GM057603-10A1	R01	STUDIES OF WNT RECEPTOR INTERACTION WITH AGONISTS AND ANTAGONISTS	HE, XI	CHILDREN'S HOSPITAL BOSTON	$425,184
5R01GM073994-04	R01	NUCLEAR MEMBRANE FUSION IN XENOPUS EGG EXTRACTS	HETZER, MARTIN W	SALK INSTITUTE FOR BIOLOGICAL STUDIES	$353,298

5R01GM072754-06	R01	MECHANISMS OF CENTROSOME REPRODUCTION IN ANIMAL CELLS	HINCHCLIFFE, EDWARD H	UNIVERSITY OF MINNESOTA TWIN CITIES	$254,722
5R01GM080993-03	R01	A CLONABLE HIGH-DENSITY FOR 3-D ELECTRON MICROSCOPY OF CELLULAR STRUCTURES	HOENGER, ANDREAS	UNIVERSITY OF COLORADO AT BOULDER	$265,125
5R01GM079427-18	R01	MOLECULAR PHYSIOLOGY OF VOLTAGE-GATED ION CHANNELS	HORN, RICHARD J	THOMAS JEFFERSON UNIVERSITY	$368,737
5R01GM083999-02	R01	LOCALIZED MRNAS IN VERTEBRATE AXIS FORMATION	HOUSTON, DOUGLAS W	UNIVERSITY OF IOWA	$281,316
1R01GM088202-01	R01	PLANAR CELL POLARITY AND THE CYTOSKELETON	JENNY, ANDREAS	ALBERT EINSTEIN COL OF MED YESHIVA UNIV	$327,776
5R01GM050806-16	R01	REGULATION OF DNA REPLICATION IN S. POMBE	KELLY, THOMAS J	SLOAN-KETTERING INSTITUTE FOR CANCER RES	$441,477
5R01GM064768-07	R01	FOX GENE REGULATION OF NODAL SIGNALING IN MESODERM DEVELOPMENT	KESSLER, DANIEL S	UNIVERSITY OF PENNSYLVANIA	$321,765
5R01GM033932-23	R01	ESTABLISHING GERM CELL FATE IN XENOPUS	KING, MARY LOU	UNIVERSITY OF MIAMI SCHOOL OF MEDICINE	$349,123
5R01GM066492-07	R01	CHEMICAL GENETIC AND BIOCHEMICAL STUDIES OF MITOTIC PROTEOLYSIS	KING, RANDALL W	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$364,246
3R01GM066492-07S1	R01	CHEMICAL GENETIC AND BIOCHEMICAL STUDIES OF MITOTIC PROTEOLYSIS	KING, RANDALL W	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$199,678
2R01GM076507-05	R01	DEVELOPMENTAL PHYSIOLOGY OF CILIATED EPITHELIA	KINTNER, CHRISTOPHER ROBERT	SALK INSTITUTE FOR BIOLOGICAL STUDIES	$416,680
5R01GM076621-04	R01	EARLY ACTIVATION OF THE ZYGOTIC GENOME	KLEIN, PETER S	UNIVERSITY OF PENNSYLVANIA	$290,572
1R01GM084133-01A1	R01	NFKB TARGETS AND NEURAL CREST DEVELOPMENT	KLYMKOWSKY, MICHAEL W	UNIVERSITY OF COLORADO AT BOULDER	$317,292
5R01GM080333-03	R01	CONTROL OF CASPASE ACTIVATION IN APOPTOSIS	KORNBLUTH, SALLY A	DUKE UNIVERSITY	$288,600

3R01GM080333-03S1	R01	CONTROL OF CASPASE ACTIVATION IN APOPTOSIS	KORNBLUTH, SALLY A	DUKE UNIVERSITY	$225,036
1R01GM088175-01	R01	REGULATION OF M PHASE EXIT	KORNBLUTH, SALLY A	DUKE UNIVERSITY	$304,130
5R01GM066815-07	R01	TRANSCRIPTIONAL REGULATION BY GEMININ	KROLL, KRISTEN L	WASHINGTON UNIVERSITY	$288,800
3R01GM066815-07S1	R01	TRANSCRIPTIONAL REGULATION BY GEMININ	KROLL, KRISTEN L	WASHINGTON UNIVERSITY	$283,295
2R01GM037949-23	R01	GROUP II INTRON MOBILITY AND GENE TARGETING	LAMBOWITZ, ALAN M.	UNIVERSITY OF TEXAS AUSTIN	$503,195
5R01GM081635-03	R01	BIOCHEMICAL RECONSTITUTION OF HETEROTRIMERIC G PROTEINS IN THE WNT PATHWAY	LEE, ETHAN	VANDERBILT UNIVERSITY	$233,234
3R01GM081635-03S1	R01	BIOCHEMICAL RECONSTITUTION OF HETEROTRIMERIC G PROTEINS IN THE WNT PATHWAY	LEE, ETHAN	VANDERBILT UNIVERSITY	$59,134
1R01GM082995-01A2	R01	THE ROLE OF THE DNA UNWINDING ELEMENT BINDING PROTEIN, DUE-B, IN DNA REPLICATION	LEFFAK, MICHAEL	WRIGHT STATE UNIVERSITY	$294,145
5R01GM077425-04	R01	BIOELECTRICAL CONTROLS OF MORPHOGENESIS	LEVIN, MICHAEL	TUFTS UNIVERSITY MEDFORD	$245,600
5R01GM078484-03	R01	BIOPHYSICAL CONTROLS OF VERTEBRATE ORGAN REGENERATION	LEVIN, MICHAEL	TUFTS UNIVERSITY MEDFORD	$295,152
5R01GM066953-07	R01	MESODERMAL CELL FATE SPECIFICATION IN C. ELEGANS	LIU, JUN	CORNELL UNIVERSITY ITHACA	$315,837
3R01GM066953-07S2	R01	MESODERMAL CELL FATE SPECIFICATION IN C. ELEGANS	LIU, JUN	CORNELL UNIVERSITY ITHACA	$26,000
5R01GM080673-03	R01	THE ROLE OF AJUBA LIM PROTEIN IN EPITHELIA BIOGENESIS	LONGMORE, GREGORY	WASHINGTON UNIVERSITY	$288,800
5R01GM055560-12	R01	MECHANISMS OF PERMEATION IN INWARD RECTIFIER K+ CHANNELS	LU, ZHE	UNIVERSITY OF PENNSYLVANIA	$373,732

5R01GM061829-10	R01	REGULATION OF CALCIUM SIGNALING DURING OOGENESIS	MACHACA, KHALED	WEILL MEDICAL COLLEGE OF CORNELL UNIV	$214,718
9R01GM088790-05A1	R01	FUNCTIONAL ARCHITECTURE OF IP3-EVOKED LOCAL CA2+ SIGNALS	MARCHANT, JONATHAN S	UNIVERSITY OF MINNESOTA TWIN CITIES	$310,732
3R01GM088790-05A1S1	R01	FUNCTIONAL ARCHITECTURE OF IP3-EVOKED LOCAL CA2+ SIGNALS	MARCHANT, JONATHAN S	UNIVERSITY OF MINNESOTA TWIN CITIES	$224,769
2R01GM067779-05A2	R01	NETWORK-DIRECTED DISCOVERY OF DISEASE GENES	MARCOTTE, EDWARD M	UNIVERSITY OF TEXAS AUSTIN	$273,600
5R01GM063004-08	R01	PROTEIN UNFOLDING IN A PHYSIOLOGICAL SYSTEM	MATOUSCHEK, ANDREAS	NORTHWESTERN UNIVERSITY	$321,695
5R01GM078247-04	R01	BEYOND GFP AND AEQUORIN: OCEAN-WIDE STUDY OF FLUORESCENT AND LUMINOUS PROTEINS	MATZ, MIKHAIL V	UNIVERSITY OF TEXAS AUSTIN	$291,735
5R01GM052112-15	R01	P120-CATENIN SUB-FAMILY FUNCTIONS	MCCREA, PIERRE D	UNIVERSITY OF TEXAS MD ANDERSON CAN CTR	$323,400
3R01GM052112-15S1	R01	P120-CATENIN SUB-FAMILY FUNCTIONS	MCCREA, PIERRE D	UNIVERSITY OF TEXAS MD ANDERSON CAN CTR	$57,411
5R01GM066270-07	R01	MOLECULAR STRUCTURE AND FUNCTION OF THE HUMAN KINETOCHORE OUTER PLATE	MCEWEN, BRUCE F	WADSWORTH CENTER	$367,392
3R01GM066270-07S1	R01	MOLECULAR STRUCTURE AND FUNCTION OF THE HUMAN KINETOCHORE OUTER PLATE	MCEWEN, BRUCE F	WADSWORTH CENTER	$71,546
2R01GM067735-06A1	R01	REPLICATION CHECKPOINT ACTIVATION AND SILENCING	MICHAEL, MATTHEW	HARVARD UNIVERSITY	$335,273
3R01GM067735-06A1S1	R01	REPLICATION CHECKPOINT ACTIVATION AND SILENCING	MICHAEL, MATTHEW	HARVARD UNIVERSITY	$267,145
5R01GM023928-31	R01	CYTOSKELETON POLYMERIZATION DYNAMICS IN THE CELL CYCLE	MITCHISON, TIMOTHY J	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$392,865
5R01GM039565-22	R01	MICROTUBULE DYNAMICS AND MITOTIC MECHANISM	MITCHISON, TIMOTHY J	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$505,486

3R01GM073887-04S1	R01	R01:WNT AND BETA-CATENIN SIGNALING IN REGENERATION	MOON, RANDALL TODD	UNIVERSITY OF WASHINGTON	$126,779
5R01GM050284-12	R01	MITOCHONDRIAL PATHWAYS IN APOPTOSIS	NEWMEYER, DONALD DAVID	LA JOLLA INST FOR ALLERGY & IMMUNOLGY	$340,947
5R01GM078244-03	R01	ELECTROPHYSIOLOGY OF PERIPHERAL NERVE SODIUM CHANNELS	O'LEARY, MICHAEL E	THOMAS JEFFERSON UNIVERSITY	$242,143
3R01GM078244-03S1	R01	ELECTROPHYSIOLOGY OF PERIPHERAL NERVE SODIUM CHANNELS	O'LEARY, MICHAEL E	THOMAS JEFFERSON UNIVERSITY	$25,000
5R01GM083025-02	R01	SPECIFICITY OF EFFECTOR ACTIVATION BY RHO FAMILY GTPASES	PETERSON, JEFFREY R	INSTITUTE FOR CANCER RESEARCH	$314,100
3R01GM083025-02S1	R01	SPECIFICITY OF EFFECTOR ACTIVATION BY RHO FAMILY GTPASES	PETERSON, JEFFREY R	INSTITUTE FOR CANCER RESEARCH	$229,307
1R01GM086526-01A1	R01	SYSTEMS ARCHITECTURE AND DYNAMICAL BEHAVIORS OF THE KINASES THAT DRIVE M-PHASE	POMERENING, JOSEPH RICHARD	INDIANA UNIVERSITY BLOOMINGTON	$269,984
5R01GM059975-09	R01	FUNCTIONAL ANALYSIS OF VERTEBRATE NUCLEAR TRANSPORT	POWERS, MAUREEN A.	EMORY UNIVERSITY	$309,966
5R01GM071760-04	R01	ROLE OF HMGA1 PROTEINS IN DNA DAMAGE AND EXCISION REPAIR	REEVES, RAYMOND	WASHINGTON STATE UNIVERSITY	$275,715
5R01GM046779-19	R01	POLYADENYLATION AND TRANSLATIONAL CONTROL	RICHTER, JOEL D	UNIV OF MASSACHUSETTS MED SCH WORCESTER	$381,875
3R01GM046779-19S1	R01	POLYADENYLATION AND TRANSLATIONAL CONTROL	RICHTER, JOEL D	UNIV OF MASSACHUSETTS MED SCH WORCESTER	$87,135
3R01GM062290-08S1	R01	REGULATION OF INTRACELLULAR TRANSPORT	RODIONOV, VLADIMIR I	UNIVERSITY OF CONNECTICUT SCH OF MED/DNT	$184,773
5R01GM080753-03	R01	FUNCTIONAL ANALYSIS OF THE BIFUNCTIONAL ION CHANNEL AND KINASE TRPM7	RUNNELS, LOREN W	UNIV OF MED/DENT NJ-R W JOHNSON MED SCH	$296,400
3R01GM080753-03S1	R01	FUNCTIONAL ANALYSIS OF THE BIFUNCTIONAL ION CHANNEL AND KINASE TRPM7	RUNNELS, LOREN W	UNIV OF MED/DENT NJ-R W JOHNSON MED SCH	$45,303

3R01GM038277-22S1	R01	HORMONAL REGULATION OF MRNA STABILITY	SCHOENBERG, DANIEL R.	OHIO STATE UNIVERSITY	$123,218
1R01GM079707-01A2	R01	NONSENSE CODON ACTIVATION OF ENDONUCLEASE-MEDIATED MRNA DECAY	SCHOENBERG, DANIEL R.	OHIO STATE UNIVERSITY	$307,500
5R01GM076112-04	R01	BUILDING A SYSTEMS-LEVEL VIEW OF CELL CYCLE CHECKPOINTS	SIBLE, JILL C	VIRGINIA POLYTECHNIC INST AND ST UNIV	$222,162
1R01GM088500-01	R01	REPROGRAMMING CELLS TO ENABLE LIMB REGENERATION	SLACK, JONATHAN M.	UNIVERSITY OF MINNESOTA TWIN CITIES	$302,000
5R01GM030758-28	R01	CENTROSOME REDUPLICATION AND CONSEQUENCES OF CLEAVAGE FAILURE/PROLONGED MITOSIS	SLUDER, GREENFIELD	UNIV OF MASSACHUSETTS MED SCH WORCESTER	$445,734
3R01GM030758-28S2	R01	CENTROSOME REDUPLICATION AND CONSEQUENCES OF CLEAVAGE FAILURE/PROLONGED MITOSIS	SLUDER, GREENFIELD	UNIV OF MASSACHUSETTS MED SCH WORCESTER	$186,599
5R01GM077592-03	R01	METASTASIS-ASSOCIATED KINASE IN WNT SIGNALING	SOKOL, SERGEI Y	MOUNT SINAI SCHOOL OF MEDICINE OF NYU	$318,660
2R01GM052022-14	R01	CENTROSOME STRUCTURE, FUNCTION AND DUPLICATION	STEARNS, TIM	STANFORD UNIVERSITY	$445,803
3R01GM052022-14S1	R01	CENTROSOME STRUCTURE, FUNCTION AND DUPLICATION	STEARNS, TIM	STANFORD UNIVERSITY	$117,773
5R01GM026154-39	R01	SMALL RNP MEDIATORS OF GENE EXPRESSION	STEITZ, JOAN A.	YALE UNIVERSITY	$272,284
3R01GM026154-39S1	R01	SMALL RNP MEDIATORS OF GENE EXPRESSION	STEITZ, JOAN A.	YALE UNIVERSITY	$24,358
5R01GM074728-05	R01	MECHANISMS OF KINETOCHORE ASSEMBLY	STRAIGHT, AARON F	STANFORD UNIVERSITY	$253,404
5R01GM081576-02	R01	MECHANISMS OF "END ON" MICROTUBULE ATTACHMENT BY THE KINETOCHORE	STUKENBERG, P. TODD	UNIVERSITY OF VIRGINIA CHARLOTTESVILLE	$273,948
3R01GM081576-02S1	R01	MECHANISMS OF "END ON" MICROTUBULE ATTACHMENT BY THE KINETOCHORE	STUKENBERG, P. TODD	UNIVERSITY OF VIRGINIA CHARLOTTESVILLE	$99,753

5R01GM076599-04	R01	TRAF4 IN TGF-BETA SIGNALING AND EMBRYONIC DEVELOPMENT	THOMSEN, GERALD H	STATE UNIVERSITY NEW YORK STONY BROOK	$290,606
5R01GM080462-03	R01	REGULATION OF TGF-BETA SIGNALING AND EMBRYONIC DEVELOPMENT BY GTPASES	THOMSEN, GERALD H	STATE UNIVERSITY NEW YORK STONY BROOK	$289,308
3R01GM074096-04S1	R01	MODEL SYNTHETIC CHANNEL ASSEMBLIES	TOMICH, JOHN M	KANSAS STATE UNIVERSITY	$80,136
5R01GM074096-04	R01	MODEL SYNTHETIC CHANNEL ASSEMBLIES	TOMICH, JOHN M	KANSAS STATE UNIVERSITY	$241,955
1R01GM088253-01	R01	THE CONTROL OF CENTRIOLE DUPLICATION AND DEGENERATION	TSOU, MENG-FU BRYAN	SLOAN-KETTERING INSTITUTE FOR CANCER RES	$361,998
2R01GM061275-10	R01	THE NUCLEAR PORE COMPLEX: INTERPHASE AND MITOTIC FUNCTION	ULLMAN, KATHARINE S	UNIVERSITY OF UTAH	$309,093
3R01GM032441-25S1	R01	DNA REPLICATION AND GENE EXPRESSION OF CHLORELLA VIRUSES	VAN ETTEN, JAMES L	UNIVERSITY OF NEBRASKA LINCOLN	$144,281
1F32GM087107-01	F32	BIOELECTRICAL CONTROLS OF LEFT-RIGHT ASYMMETRY	VANDENBERG, LAURA N.	TUFTS UNIVERSITY MEDFORD	$47,210
5R01GM054179-11	R01	MECHANISMS OF GATING AND PERMEATION IN GAP JUNCTIONS	VERSELIS, VYTAUTAS K	ALBERT EINSTEIN COL OF MED YESHIVA UNIV	$319,550
5R01GM074104-05	R01	MECHANISM OF VERTEBRATE NEURAL TUBE MORPHOGENESIS	WALLINGFORD, JOHN B	UNIVERSITY OF TEXAS AUSTIN	$280,998
1R01GM086627-01	R01	DEVELOPMENTAL CONTROL OF CELL POLARITY IN VERTEBRATE EMBRYOS.	WALLINGFORD, JOHN B	UNIVERSITY OF TEXAS AUSTIN	$265,176
5R01GM062267-09	R01	PROPERTIES OF THE EUKARYOTIC REPLICATIVE DNA HELICASE	WALTER, JOHANNES	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$337,398
5R01GM080676-03	R01	CELL CYCLE REGULATION OF VERTEBRATE DNA REPLICATION	WALTER, JOHANNES	HARVARD UNIVERSITY (MEDICAL SCHOOL)	$322,050
5R01GM081489-02	R01	ROLE OF UBP-M AND H2A DEUBIQUITINATION IN CHROMATIN AND CELLULAR FUNCTION	WANG, HENGBIN	UNIVERSITY OF ALABAMA AT BIRMINGHAM	$267,525

3R01GM081489-02S1	R01	ROLE OF UBP-M AND H2A DEUBIQUITINATION IN CHROMATIN AND CELLULAR FUNCTION	WANG, HENGBIN	UNIVERSITY OF ALABAMA AT BIRMINGHAM	$202,813
5F32GM083542-02	F32	MECHANOSENSITIVE SIGNALING AND CELL ADHESION DURING MIGRATION	WEBER, GREGORY	UNIVERSITY OF VIRGINIA CHARLOTTESVILLE	$50,054
5R01GM061671-08	R01	SIGNALING MECHANISMS COORDINATING CELL FATE DETERMINATION AND MORPHOGENESIS	WEINSTEIN, DANIEL	QUEENS COLLEGE	$306,900
5R01GM065232-06	R01	STUDYING THE ROLE OF RAN IN MITOSIS	HEALD, REBECCA W;WEIS, KARSTEN ;	UNIVERSITY OF CALIFORNIA BERKELEY	$327,385
5R01GM072915-04	R01	MECHANISMS OF ENDODERM SPECIFICATION ALONG THE A-P AXIS	WELLS, JAMES M	CHILDREN'S HOSPITAL MED CTR (CINCINNATI)	$276,735
5R01GM057438-11	R01	REGULATION OF NUCLEAR PORE COMPLEX ASSEMBLY	HETZER, MARTIN W;WENTE, SUSAN R. ;	VANDERBILT UNIVERSITY	$459,814
3R01GM050942-13S1	R01	FUNCTION OF 3'UTRS	WICKENS, MARVIN P.	UNIVERSITY OF WISCONSIN MADISON	$473,266
3R01GM073863-04S1	R01	RNA QUALITY CONTROL AND ENVIRONMENTAL STRESS	WOLIN, SANDRA L.	YALE UNIVERSITY	$78,408
5R01GM056238-11	R01	BIOLOGICAL ROLES OF NODAL RELATED GENES IN EMBRYOGENESIS	WRIGHT, CHRISTOPHER V.	VANDERBILT UNIVERSITY	$337,700
2R01GM057962-10A2	R01	WERNER SYNDROME PROTEIN, DNA END PROCESSING, AND DOUBLE-STRAND BREAK REPAIR	YAN, HONG	INSTITUTE FOR CANCER RESEARCH	$388,208
1R01GM085234-01A1	R01	ASSEMBLY OF POLYCYSTIN COMPLEXES	YANG, JIAN	COLUMBIA UNIV NEW YORK MORNINGSIDE	$328,120
3P01GM048677-17S1	P01	ELECTROPHYSIOLOGY & IMAGING CORE	YOSHIKAMI, DOJU	UNIVERSITY OF UTAH	$171,751
5R01GM061542-09	R01	REGULATION OF THE ANAPHASE-PROMOTING COMPLEX BY THE SPINDLE CHECKPOINT	YU, HONGTAO	UNIVERSITY OF TEXAS SW MED CTR/DALLAS	$304,894
3R01GM061542-09S1	R01	REGULATION OF THE ANAPHASE-PROMOTING COMPLEX BY THE SPINDLE CHECKPOINT	YU, HONGTAO	UNIVERSITY OF TEXAS SW MED CTR/DALLAS	$85,000

5R01GM062937-09	R01	SPLICEOSOMAL SNRNA MODIFICATION IN XENOPUS OOCYTES	YU, YI-TAO	UNIVERSITY OF ROCHESTER	$272,657
5R01GM084879-02	R01	EVOLUTION OF SODIUM CHANNEL GENES	ZAKON, HAROLD H	UNIVERSITY OF TEXAS AUSTIN	$296,800
3R01GM084879-02S1	R01	EVOLUTION OF SODIUM CHANNEL GENES	ZAKON, HAROLD H	UNIVERSITY OF TEXAS AUSTIN	$271,398
5R01GM083889-13	R01	MECHANISMS OF GROWTH CONE TURNING IN DIFFUSIBLE GRADIENT	ZHENG, JAMES Q	EMORY UNIVERSITY	$341,000
5R01GM084363-02	R01	DIRECTED GROWTH CONE MIGRATION BY CALCIUM SIGNALS	ZHENG, JAMES Q	EMORY UNIVERSITY	$262,880
3R01GM084363-02S1	R01	DIRECTED GROWTH CONE MIGRATION BY CALCIUM SIGNALS	ZHENG, JAMES Q	EMORY UNIVERSITY	$60,000
5R01GM081492-03	R01	MECHANISMS OF DIFFERENT WNT SIGNALS	ZHENG, JIE J.	ST. JUDE CHILDREN'S RESEARCH HOSPITAL	$310,800
5P01GM047969-18	P01	PHYSIOLOGICAL STUDIES OF NEUROSTEROID ANALOGUES	ZORUMSKI, CHARLES F	WASHINGTON UNIVERSITY	$348,917

Total: $43,883,452