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YALE UNIVERSITY

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August 8, 2007

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Gordon M. Aamoth, M.D.
President and Chief Executive
Robina Foundation
4900 IDS Center, 80 South 8th Street
Minneapolis, MN 55402

Dear Dr. Aamoth:

I want to convey my sincere thanks to you and the Board of the Robina Foundation for your willingness to review Yale's three preliminary proposals. I was in China as my staff prepared the drafts and sent the package, but I want to reiterate that the plans presented — for theatre arts, nanoscience, and genomics — represent University priorities and, in our assessment, hold special potential to make a significant impact on their respective fields now and over the coming decades at Yale and beyond.

In choosing these options, we have carefully considered the Foundation's and its founder, James Binger's, aims of supporting endeavors that are ambitious in scope, forward-thinking, and promise far-reaching benefits for the arts, sciences, and medicine. In meeting these goals, each project describes a plan of action that contains within it the kernel of larger, long-term initiative. The proposed initiatives leverage Yale's unique strengths in research and education; and they aim to make a difference in the world by hastening discoveries or by facilitating new forms of artistic expression and interpretation.

I am grateful for your consideration of the project ideas we have presented. And, once you have had an opportunity to review them, I look forward to working with you on the next steps toward achieving our shared goals.

With my best regards,

Sincerely yours,

Richard C. Levin

Richard C. Levin

RCL:mg



Yale University

OFFICE OF DEVELOPMENT

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August 2, 2007

Gordon M. Aamoth, M.D.
President and Chief Executive
Robina Foundation
4900 IDS Center, 80 South 8th Street
Minneapolis, Minnesota 55402

Dear Dr. Aamoth:

I want to convey my deep appreciation for the invitation to submit the enclosed preliminary proposals for review by the Board of the Robina Foundation—this, I understand, is in advance of a final evaluation at a later Board meeting in November. We look forward to receiving your comments and guidance regarding the next steps.

The Robina Foundation has given President Levin and Yale's senior leadership a unique and wonderful opportunity to evaluate our strategic funding priorities and to prepare proposal drafts in three areas that align with James Binger's breadth of vision for the Foundation that you shared with us in your mission statement. Program ideas were solicited from the Schools of Drama, Medicine (genomics), and Engineering (nanoscience). While very different in terms of their substance and immediate aims, each builds on unique strengths and reserves of talent and expertise at Yale; and each holds enormous long term potential for fostering creative thinking, innovation, and excellence. To various degrees, they are collaborative; and each proposes to leverage support in the near term into initiatives with long range significance for meeting Yale's enduring core needs and interests while extending the impact of the work of the University outward.

We are honored by the invitation, grateful for your advice and encouragement, and very excited by the prospects of working with the Robina Foundation to develop a proposal and, hopefully, launch an initiative that will yield far-reaching benefits for our institution and for advancing our creative, intellectual, research, and educational mission.

I look forward to hearing from you.

Sincerely yours,

Inge T. Reichenbach

Encl.

cc: Richard C. Levin

The Yale Center for New Theatre

Long recognized for pioneering achievements in American theatre, Yale School of Drama and Yale Repertory Theatre are poised to undertake two transformative and complementary initiatives: the establishment of a Center for New Theatre, which will strengthen training for the professional theatre and support the creation of new works for the stage; and the building of a comprehensive facility combining performance space with classrooms, workshops, and dedicated rehearsal areas to ensure the long-term vitality of the profession and enable theatre productions of the highest quality.

Overview

Writing for the stage and staging theatre productions—at opposite ends of the artistic form—have always benefited from close collaboration, from shared understanding of the demands and creative potential of shepherding an idea for a play through the entire production process. Such understanding is even more productive and conducive to innovation when aspiring writers, directors, technicians, and theatre managers can train together and are given opportunities to apply their skills in the staging of dramatic spoken and lyric performances.

This belief has been a guiding principle of the Yale School of Drama and Yale Repertory Theatre, and it is the central proposition behind the proposed Center for New Theatre. Its goals are to increase and enhance the opportunities for playwrights, composers and lyricists at all stages of their careers, from students to established artists, to learn the craft, hone their skills, and create new works for the stage. In the short-term, the Center will give a greater number of artists the resources and inspiration needed to pursue their vision. Over the long run, the plans under way to construct a new state-of-the-art facility containing classrooms, rehearsal space, and a theatre, will leverage the combined talents and dedication of Yale's theatre arts community to make the Center for New Theatre into a major focal point of a thriving and dynamic American theatre movement across the country.

Yale School of Drama/Yale Repertory Theatre

Since its founding in 1926, Yale School of Drama has been committed to training students in every discipline of the theatre, and, today remains the only graduate school in the nation to do so. The School helped nurture the talents of Elia Kazan, T. Edward Hambleton, Julie Harris, Meryl Streep and Paul Newman, among others; at the same time, it served for 40 years as the nation's premiere laboratory for theatre technology.

In 1966, the School realized a longstanding goal when it established in a renovated former church building the Yale Repertory Theatre (the Yale Rep) as the first professional-quality theatre on an American university campus. Since then, training at the School has been explicitly tied to the demands of theatrical professions. By shifting to a conservatory model, Yale assumed a leadership role in training and in helping to establish dramaturgy and theatre management as professional disciplines. To date, the Yale Rep has staged more than 100 world, American and regional premieres of plays by

writers including Christopher Durang, Athol Fugard, David Rabe, Sarah Ruhl and August Wilson.

Project Timetable and Plans

Plans for establishing the Center for New Theatre have taken shape over the past four years in recognition of the need to encourage new production: the goal is to increase the number of commissioned plays and musicals from two per year to eight. Support for new productions by emerging and established playwrights should give a significant boost in the number of premieres staged, especially among the nation's regional theatre companies—a key consideration in ensuring the long-term vitality of the art. The new Center also aims to enhance the training of student artists, and includes a plan to create the first set of integrated training courses dedicated exclusively to musical theatre. This unique opportunity for strengthening theatre arts builds, in part, on the extensive professional experience of Yale drama faculty, by giving them the opportunity to work more closely with students on the specific tasks of writing plays and bringing them to production. In part, too, the prospects for success of the proposed Center derive from access. Every year over a hundred leading artists in the field come to the School of Drama or the Yale Rep for performances or to host workshops and discussions, lending their advice and encouragement to students. This commitment to enhancing educational and creative opportunities for students and visiting artists and to sustaining innovation, exploration, and excellence in the theatre arts reflects the School's mission as well as the University's more generally.

In addition, plans for the Center for New Theatre will be enhanced and supported by a new and dedicated facility to house the currently dispersed classrooms, rehearsal space, and performance halls, including a new Yale Rep (to replace the existing building that was never been intended as permanent home). Such a facility, which is a major objective of the University's current Yale Tomorrow campaign, will foster more formal as well as informal interactions among students and faculty, and will enable the School to maintain the highest standards of teaching and training excellence; it will permit program growth, encourage intensive mentoring of young talent, and ensure that the theatre remains a dynamic and thriving force in American arts.

Project Budgetary Overview

Funding of the Yale Center for New Theatre involves a short-term and a longer-term need.

	1 – 3 years	5 years
New Theatre - Programmatic Support		
New Theatre Facility		
Total	\$ 2.0 M	\$ 30 M

As noted above, the immediate programmatic support for the Yale Center for New Theatre is \$1.2 million, with an additional \$0.8 million to serve as a “wasting endowment” to help sustain it over a longer period until a permanent endowment fund can be raised. A long-term request of \$30 million, over a five-year period, would go toward the construction of the consolidated School of Drama and Yale Rep facility.

Short-term Request

- **The Yale Center for New Theatre – Programmatic Support**

As noted, programmatic support for the Center will increase commissions of new plays and musicals from the current average of two per year to eight. A number of playwrights whose works are commissioned will be offered fellowships at the School; as part of their responsibilities, they will be enlisted to conduct seminars and teach courses. In addition, programmatic support will cover the cost of creating integrated training courses for musical theatre as well as for readings and workshops by visiting playwrights and student productions. Included in the short-term request are funds for a new position of Literary Manager to facilitate program operations. This person will assist the Dean of the School of Drama and work closely with the Associate Artistic Director of the Yale Rep in the selection of pieces for commission, in communicating with the playwrights, and in the coordination of course planning in addition to program workshops, lectures and presentations.

Long-term Request

- **Yale School of Drama and Yale Repertory Facility**

A site has been selected and planning is under way for a new facility that will permit much-needed consolidation of activities under one roof. These activities now are dispersed over portions of 10 buildings, only one of which is designed specifically for drama. The new facility will occupy approximately 95,000 square feet and replace as much as 70% of the scattered space presently occupied by the School.

Funding the design and construction of the new facility is a major goal of the Yale Tomorrow campaign. As plans progress, Yale would welcome the opportunity to submit to the Robina Foundation a proposal for support in the amount of \$30 million toward the construction of the new theatre within the proposed building. For a gift of this magnitude, we would hope to explore with the Foundation appropriate naming opportunities for the theatre space or even for the entire building in recognition of James H. Binger’s generosity, his personal and professional interests in the theatre, and his dedication to his alma mater.

Expected Impact

The creation of the Yale Center for New Theatre will invigorate American playwriting and production by increasing the number of newly commissioned works available for performance and by honing the skills and nurturing the careers of playwrights. It will also help ensure the tradition of innovation and excellence in teaching at Yale and inspire students as well as prepare them for careers in the field. Short-term plans for the Center

also provide impetus to, and urgency for, the University's long-term commitment to creating a new dedicated theatre arts building, with a state-of-the-art space for the Yale Rep, classrooms, and a range of rehearsal and work areas. Such a facility will help the School of Drama better meet one of its founding goals: creating a conservatory model educational program for new playwrights and theatre professionals which integrates all facets of writing, design, and production in order to nurture their creative abilities and allow them to give shape and tangible form to their artistic imaginations.

Functional Genomics at Yale University

Functional genomics offers the prospect for highly exciting and promising advances in biomedicine. Thus, a pioneering project has been launched at Yale to define the function of every gene in the mammalian genome. Made possible by a major breakthrough in 2005 in genetic technology, this project equals in scope the widely heralded sequencing of the human genome, which ranks as one of the major scientific achievements in recent times. The work will take place in a new Center for Functional Genomics at Yale, and will yield fundamental insights into the molecular mechanisms of mammalian development, physiology, and pathophysiology. Research at the Center is expected to pave the way for a new generation of improved diagnostics and therapies for human disease.

Overview

Targeting genes that underlie human disease has been a promise of biomedical research for many years. An important step toward this goal was achieved in 2003 with the sequencing of the human genome, which identified and mapped the ~30,000 genes that make up our genetic heritage. The next step will be to gain an equally comprehensive view of gene function by analyzing the changes in development, anatomic structure, and organ physiology that take place when each of the 30,000 genes is mutated, one at a time. This is a challenging task, which must necessarily be carried out in a model mammalian organism such as the mouse, which is suitable for genetic research. Until now, such studies have been limited by the time-consuming and expensive methods needed to create mutations. Engineering single gene mutations in mice has typically cost as much as \$100,000.

In 2005, a team of scientists at Yale University and Fudan University, China, led by Tian Xu, Ph.D., Professor of Genetics at Yale School of Medicine, an Investigator of the Howard Hughes Medical Institute and the Director of The Fudan Institute of Developmental Biology and Molecular Medicine, devised a powerful new technology for mouse mutagenesis, opening the door for a genome-wide functional mapping project. Working together, researchers at Yale and Fudan Universities are building on this discovery to revolutionize our understanding of gene function in the mammalian genome. Yale's Center for Functional Genomics will serve as a nucleus for the study of mammalian biomedical research worldwide over the next several decades.

Functional Genomics at Yale: Progress to Date

Professor Xu's breakthrough discovery relies on short, mobile segments of DNA called "transposons," which have the ability to insert into the genome and inactivate individual genes in a highly specific way. Until recently, transposon mutagenesis had been widely employed in lower organisms such as bacteria and fruit flies, but had not been successfully adapted for mammals such as the mouse. In 2005, however, the Xu team developed a streamlined, highly efficient technique, based on a transposon called *piggyBac*, to knock out single mouse genes (see enclosed *Cell* 122: 473-483, 2005).

In collaboration with colleagues in China, Dr. Xu has established a large-scale production unit affiliated with The Fudan Institute of Developmental Biology and Molecular Medicine at Fudan University. Using the *piggyBac* technology, the Institute is tasked with generating a comprehensive set of mutant mouse embryos which are frozen and subsequently transported to Yale where they will be bred for phenotypic evaluation. Yale is superbly positioned for this endeavor having a proven track record in characterizing and phenotyping across a wide variety of disciplines.

The Xu group has used *piggyBac* mutagenesis to create more than 500 mouse lines, each bearing a knock-out mutation in a single gene. Approximately one-fifth of the mutations have proved to be lethal, serving to pinpoint genes that are crucial for embryonic development. Of the rest, many exhibit visible phenotypes ranging from anatomic abnormalities such as skeletal malformations to defects in autoimmunity and neurological function. These results have demonstrated the feasibility of the transposon-based approach for a full-scale functional mapping project.

Project Timetable and Plans

The Center for Functional Genomics will be located at Yale's recently acquired 136 acre West Haven campus, the former research campus of Bayer. The site includes half a million sq. ft. of research and office space including state-of-the-art laboratories and a large vivarium. This campus will serve as a valuable resource not only in providing infrastructure for this and other scientific endeavors, but will also serve as a scientific hub for intellectual growth and expansion. This important resource will provide outstanding opportunities for leveraging additional funding. Work is underway to select the specific space for assignment to the new Center. In parallel, a steering committee of basic science and clinical investigators is being formed to advise Professor Xu throughout the project.

Phase 1 (Year 1)

The first year will focus on determining the optimal strategy for high-throughput screening of mutant strains in order to obtain a maximum amount of data in the most affordable and efficient way. Each mutant mouse will undergo an exhaustive "physical exam" that includes structural imaging, clinical chemistry, organ function tests, and behavioral assays. Professor Xu and his Yale collaborators have spent the past year consulting with colleagues throughout the United States and Europe to develop the most appropriate battery of assays. During Phase 1, staff will be hired, equipment installed, and tests developed to handle an initial workflow of 50 to 100 mutant mouse strains at a time.

Phase 2 (Years 2-6)

Vigorous efforts are underway to increase throughput, however, and we expect the rate of screening to accelerate significantly during this period. By scaling up the workflow, Yale scientists currently expect to screen at least 1,000 mouse strains per year in Phase 2. The target is to complete at least one-half of the genome by the end of Phase 2. After careful documentation, the mutant mouse lines will be made available to researchers around the world, establishing Yale as a central resource for distribution of these unique animal research models.

Phase 3 (Years 7-15)

Genetic screening is likely to continue during Phase 3, however and in parallel, it is expected that Yale investigators will choose subsets of mutant lines to characterize in greater detail through additional mutations and phenotyping tests. The wealth of opportunities for such studies means that the Center for Functional Genomics will be at the forefront of research into the genetic basis of disease for many years to come.

Project Budgetary Overview

Launching the Center for Functional Genomics and embarking on the initial phase of operations will cost an estimated \$ 3 million.

	Phase 1 (1 yr)	Phase 2 (5 yrs)	Phase 3 (9 yrs)
Facilities	→ \$ 1.50 M →		
Salaries	→ \$ 0.75 M →	\$ 3.75 M →	\$ 3.75 M →
Animal Husbandry		\$ 17.50 M →	\$17.50 M →
Project Development	→ \$ 0.75 M →	\$ 10.00 M →	\$ 10.00 M →
Total	\$ 3.00 M	\$ 31.25 M	\$ 31.25 M

Plans for funding the anticipated 15-year, \$ 65.5 million project will draw equally from private funding sources, the University, and other external sources.

Short-term Request

- **Phase 1: Center for Functional Genomics – Start-up Costs**

The immediate challenge is to create a battery of phenotyping tests that give the maximal amount of data in a streamlined, affordable way. For this purpose, Yale seeks support of \$ 3 million from the Robina Foundation for Phase 1. Equipment and facilities costs for the Center for Functional Genomics will require an initial investment of \$ 1.5 million. An additional \$ 1.5 million will allow researchers to set up the facility and develop strategies to screen and formulate tests to phenotype the mutants generated in China. Support for Phase 1 will facilitate Yale's ability to obtain the required funds to expand the project and realize our goals.

Long-term Request

- **Phases 2 and 3: Center for Functional Genomics – Programmatic Support**

The long-term goal is to establish an international research center with the capacity to explore, expand and share functional genomic information for the advancement of biomedical research. Current estimates call for an annual operating budget of \$ 6.25 million to screen 1,000 mouse strains per year. Of this amount, \$ 750,000 is needed for staff salaries, \$ 2 million for reagents and

supplies, and \$ 3.5 million for animal husbandry, annually. It is anticipated that the cost-per-strain will decrease over time as streamlined methods are put in place; in this event, the throughput will rise significantly, accelerating scientific discoveries. It is our hope that the Robina Foundation will consider funding in the \$ 30 million range for the subsequent two phases of the project.

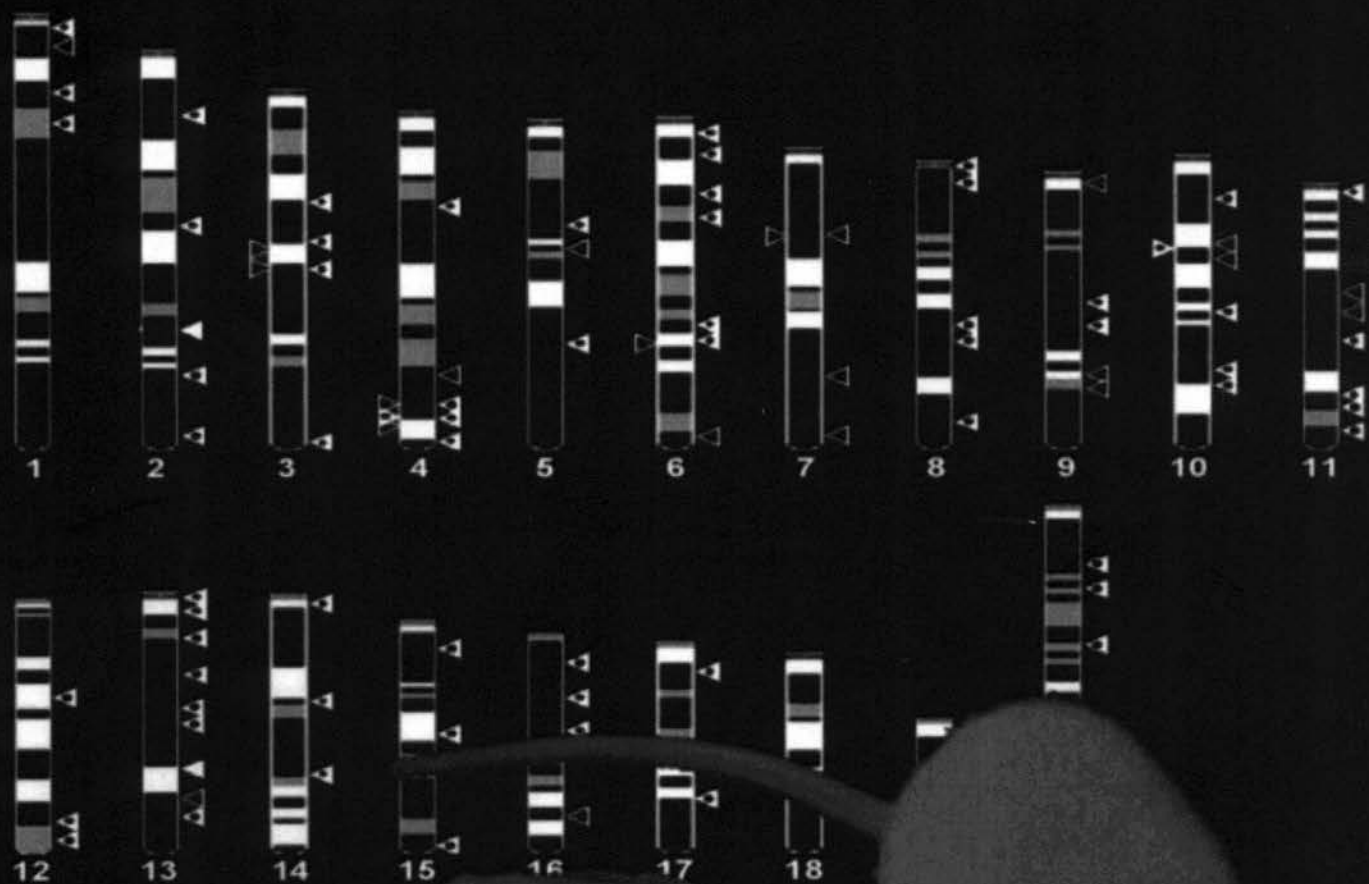
Expected Impact

At least 6,000 human diseases are believed to be caused by single-gene mutations. Some are "orphan" diseases that afflict a small percentage of the population and receive little attention from public funding agencies and pharmaceutical companies. Others are more common, including spinal cord deformities, hydrocephalus, polycystic kidney and ovary syndromes, and endometriosis. Mutant mice generated at Yale's Center for Functional Genomics will provide a simple way to uncover the mechanisms of these conditions. Equally important, the wide usage of the library of mouse strains will shed light on the genetic basis for common polygenic disorders such as diabetes, cardiovascular disease, neurodevelopmental and neurodegenerative diseases, and cancer. Through collaborations with biomedical researchers at Yale and around the world, the Center (to be named after the donor) will accelerate the development of new therapies to treat these diseases, which collectively exact a high toll on human health and well-being.

Cell

Volume 122 Number 3

August 12, 2005



piggyBac Transposon Jumps
in Mammalian Genomes

Efficient Transposition of the *piggyBac* (PB) Transposon in Mammalian Cells and Mice

Resource

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Summary

Transposable elements have been routinely used for genetic manipulation in lower organisms, including generating transgenic animals and insertional mutagenesis. In contrast, the usage of transposons in mice and other vertebrate systems is still limited due to the lack of an efficient transposition system. We have tested the ability of *piggyBac* (PB), a DNA transposon from the cabbage looper moth *Trichoplusia ni*, to transpose in mammalian systems. We show that PB elements carrying multiple genes can efficiently transpose in human and mouse cell lines and also in mice. PB permits the expression of the marker genes it carried. During germline transposition, PB could excise precisely from original insertion sites and transpose into the mouse genome at diverse locations, preferably transcription units. These data provide a first and critical step toward a highly efficient transposon system for a variety of genetic manipulations including transgenesis and insertional mutagenesis in mice and other vertebrates.

Introduction

Transposable elements or transposons are mobile genetic units identified in many metazoa, including worms, insects, and humans. In humans and mice, transposon-derived sequences account for more than 40% of the genome (Lander et al., 2001; Waterston et al., 2002), indicating the importance of transposition in evolution.

Since the discovery of the first transposon in maize by McClintock (McClintock, 1950), transposable elements have become invaluable tools for genetic analysis in many organisms. In prokaryotes, transposon-based mutagenesis has led to discovery of genes important for microbial pathogenesis (Hutchison et al., 1999; Vilen et al., 2003). In eukaryotes, the introduction of P element-mediated transgenesis and insertional mutagenesis dramatically advanced *Drosophila* genetics (Rubin and Spradling, 1982). Many transposons, including P elements, are nonfunctional outside their natural hosts, suggesting host factors are involved in transposition (Handler et al., 1993).

Transposition systems, including members from the *Tc1/Mariner* family, have been used in mouse and the zebrafish *Danio rerio*. By using a comparative phylogenetic approach, a synthetic Tc1-like transposon *Sleeping Beauty* (SB) has been proven active in mouse and human cells (Ivics et al., 1997; Luo et al., 1998). Although transposons such as SB and *Minos* have been tested for insertional mutagenesis in mouse (Dupuy et al., 2001; Fischer et al., 2001; Horie et al., 2001; Zagoraiou et al., 2001), general application of these transposons in mouse genetics was limited due to the fact that new transposon insertions were heavily concentrated near the original site, occurred with low efficiencies, and had a limited capacity to carry DNA fragments (Drabek et al., 2003; Dupuy et al., 2001; Fischer et al., 2001; Horie et al., 2001, 2003; Zagoraiou et al., 2001).

PB elements are 2472 bp transposons with 13 bp inverted terminal repeats (ITRs) and a 594 amino acid transposase (Cary et al., 1989; Fraser et al., 1995, 1996). These elements have been successfully used for genetic analysis in *Drosophila melanogaster* and other insects. It was found that PB transposons insert into the tetranucleotide TTAA site, which is duplicated upon insertion (Fraser et al., 1995, 1996). Because of the unique transposase and TTAA target-site sequences, the transposon has been suggested as the founding member of a new DNA transposon family, called the *piggyBac* family (Robertson, 2002). PB elements have been used to transform the germline of more than a dozen species spanning four orders of insects (Handler, 2002; Sumitani et al., 2003). As a mutagen, PB transposes at least as effectively as the P element in *Drosophila* (Thibault et al., 2004). In the red flour beetle *Tribolium castaneum*, *piggyBac* transposition also efficiently occurred between nonhomologous chromosomes (Lorenzen et al., 2003). Many PB element-like sequences have been found in the genomes of phylogenetically diverse species from fungi to mammals, further indicating that their activity may not be restricted to insects (Sarkar et al., 2003). In fact, PB has recently been shown capable of transposition in the planarian *Girardia tigrina* (Gonzalez-Estevez et al., 2003).

In order to develop efficient transgenesis and insertional mutagenesis tools for the mouse, we have explored a variety of transposons and retroviruses. We reasoned that PB-mediated transposition may be less dependent on host factors and thus may also work in

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Nanoscience at Yale University

Nanoscience is widely recognized as the field with the potential to have a transformative impact on the world's health and well-being. Yale's contribution to nanoscience, with the recent establishment of the Yale Institute for Nanoscience and Quantum Engineering and plans for dramatically increasing research capacity, will generate important breakthrough methods and technologies, foster new collaborations, and lay the foundation for creative discoveries and advances. The Yale Institute for Nanoscience and Quantum Engineering provides unprecedented opportunities to address some of the greatest challenges facing human society.

Overview

Nanoscience refers to phenomena, processes, and applications that take place on the scale of a nanometer, one billionth of a meter—essentially, a few atoms wide. At this size and scale, the fields of physics, chemistry, and biology merge. By connecting these disciplines, nanoscience is revolutionizing approaches to materials production and design and significantly broadening fields of application—from medicine to environmental sciences. Recent advances in working at this level are opening new vistas for research, expanding possibilities for innovative techniques and for integrating nanotechnologies and devices, even biomolecules, into all facets of life. These advances have created extraordinary possibilities as well as a corresponding need for scientific disciplines to work together to explore and harness the potential of this rapidly evolving field.

The Yale Institute for Nanoscience and Quantum Engineering

In recognition of the increasing importance of nanoscience, Yale University established the Yale Institute for Nanoscience and Quantum Engineering (YINQE) in 2006 to coordinate and facilitate a more comprehensive, campus-wide nanoscale research initiative. YINQE provides the infrastructure and serves as a catalyst for interdisciplinary research collaborations in nanoscience. The Institute aims to place Yale among the world's leaders in this field by strengthening existing areas of excellence and providing new physical and intellectual capabilities that will nurture collaborations and leverage the creative potential of Yale scientists.

Support for YINQE began with a commitment of \$5.5 million over three years in start-up funds for equipment, seed projects, seminars, symposia, and curriculum development. YINQE operates not as a typical research center devoted to supporting specific principal investigators working in particular areas. Rather, through shared facilities and support from core technical groups, it serves as a nexus for cross-collaborations that strengthen links between physical scientists and the medical, biological, biochemical, and engineering research communities at Yale. The Institute encourages innovative projects that build on deep disciplinary knowledge from multiple fields to devise solutions to fundamental problems in the environment, energy, communications, computing, and global health. Projects now underway at Yale are leading to the design of polymer scaffolds for facilitating nerve cell repair and regeneration, improved vaccine delivery systems, and nanostructure membranes to be used in forward or reverse osmosis for desalination and remediation of water pollution. Others are focusing on global

climate change and emissions reduction strategies, developing greener and more efficient manufacturing methods, and engineering biocomputers and nanosensing devices.

YINQE also meets the growing educational needs and interests of Yale undergraduates and graduate students who are flocking to courses in the field and who promise to be in the vanguard of the nanoscience revolution. Notably, biomedical engineering and environmental engineering are two of the fastest growing majors on campus, while *Introduction to Nanoscience* is one of the most popular undergraduate courses at the University.

Project Timetable and Plans

Support from the Robina Foundation will help put Yale near the forefront of nanoscience research by giving scientists the resources, encouragement, equipment, and physical space for pursuing new avenues for investigation and collaboration. Support in the short term can be expected to foster dramatic growth in long-term opportunities both for basic research and nanotechnology applications. With demand for funding and equipment exceeding present capacity, the University is at a critical juncture. Meeting the challenge will enable the University to attract and retain world-class faculty and students, while providing the opportunity for Yale scientists to broaden the scope of nanoscale research and investigation, draw together disparate areas of expertise and interest, and prepare the next generation of leaders in the field. The projects presented below represent the best opportunities for leveraging short-term nanoscience support for the greatest long-term benefits, culminating in a new state-of-the-art facility for engineering and nanotechnology at Yale.

Project Budgetary Overview

For the greatest short-term and long-term impact, requested support for nanoscience research at Yale can be spread out over several years.

	1 – 4 years	5 – 15 years
Seed Project Funding	\$ 0.75 M →	
Electron Beam Writer	\$ 1.2 M →	
New Engineering Building		\$ 30 M →
Total	\$ 1.95 M	\$ 30 M

Support for the entire request would amount to \$ 31.95 million.

Short-term Request

- **Seed Project Funding**

In the first, recently completed competition for Seed Project Funding from YINQE, we received 22 proposals from 40 faculty across all science and engineering departments with collaborators from both the Schools of Medicine and Forestry and Environmental Studies—an indicator of both enormous interest and need. The projects proposed are diverse and have implications in medicine, biomedical engineering and diagnostics, the

environment and safety, energy, and information technology. (More details on some of Yale's existing projects and initial initiatives in nanoscience can be found on the YINQE website at <http://www.nano.yale.edu>.)

Unfortunately, funding any substantial number of the proposals received in this first round would nearly exhaust the entire three-year YINQE Seed Project budget, a limitation preventing funding for many proposals from our most promising scientists. Because YINQE's principal mission is to stimulate new kinds of strongly interdisciplinary collaborations, additional Seed Project Funding would have the most immediate and critical impact on achieving the Institute's goals. The more worthy projects that can be initiated in the early phase of YINQE, the greater the prospect for mid- to long-term success and for the researchers' initial concepts to grow to the level of greater societal importance. An award of \$750,000 from the Robina Foundation will galvanize the YINQE Seed Project RFP cycles and ensure funding for the most promising research.

- **Electron Beam Writer for Nanostructure and Device Fabrication**

To realize the advancement of nanoscience at YINQE, infrastructure support in the form of a semiconductor processing clean room and an Electron Beam Writer for Nanostructure and Device Fabrication (EBW) is critical. Yale recently completed a major investment with the renovation of our semiconductor processing Clean Room, the ultra-clean and controlled environment required to make computer chips. The new Clean Room not only serves the dramatic increase in faculty and student research, but also brought to campus a capability for fabrication of electronic and opto-electronic circuits that is comparable to that of our peer institutions. Although the Clean Room provides competitive photo-lithography and other processing tools sufficient to design and build such circuits, it does not have the means to generate masks or to write features on the deep sub-micron or nanometer scale.

An Electron Beam Writer (EBW) for Nanostructure and Device Fabrication would fill this gap. It will provide unmatched flexibility in designing and building nanoscale structures from a virtually unlimited variety of chemical constituents, enable new kinds of cross-disciplinary research, and complement the capabilities afforded by the Clean Room for dozens of additional users. Administered by the YINQE technical staff, the EBW would be housed in the low-vibration laboratory already reserved in the new Malone Engineering Center. The acquisition of the EBW would immediately establish our nanoscience efforts at a new level. Moreover, the site for the EBW in Yale's new landmark building, the Malone Engineering Center, is at the heart of the campus, providing a highly visible naming opportunity to recognize the generosity of Mr. Binger and the Robina Foundation.

Long-term Request

- **New Building for Engineering and Nanotechnology to House Core Equipment for YINQE**

Sustaining and encouraging the dramatic increase in faculty and student interest and expertise in nanoscience at Yale will require the construction of a new, high technology

engineering building. Such funding will allow the University to house not only core equipment but also the expanding numbers of faculty and students. It will also provide centralized research and educational facilities to meet the needs of the diverse scientific disciplines involved and leverage recruitment of key faculty.

A site has been identified and affords a unique development opportunity because of its location, size and shape. The site, which is owned by Yale, is centrally located and in close proximity to existing engineering facilities, allowing easy access, use of equipment, and communication among researchers and students. Moreover, it is architecturally ideal for the construction of a state-of-the-art science facility. Currently, Yale is looking for funding to complete such a building by 2011.

Expected Impact

Nanoscience represents perhaps our best hope for tackling many of the seemingly intractable problems facing the world: from engineering tissues to expanding computing capacity; from responding more effectively to global climate change and pollution to meeting the threats from bioterrorism. The above requests will have both immediate and long-term impact on advancing nanoscience and its applications. The enhanced Seed Project Funding will nearly double the number of new projects that can be started, benefiting not only Yale students and faculty, but also the new fields and discoveries that will emerge. The Electron Beam Writer will have both immediate and long-lasting positive impact on the kinds of research that may be conducted on the Yale campus, thereby encouraging faculty from every field to extend their research horizons and to think more broadly about new opportunities for structures, materials, and devices at the nanoscale level than would otherwise be possible. Coupling transformative science with the opportunity to effect societal gain is also likely to be a compelling draw for new students into the sciences affording opportunities for them to obtain first-hand experience in conducting research in nanoscience laboratories.

On a long-term scale, support for a new engineering building would have the greatest and most lasting impact on nanoscience and nanotechnology at Yale and beyond. Such a dedicated facility will meet YINQE's evolving, long-term educational and research needs. In recognition of such a transformative gift, the new building will provide a wide range of highly visible naming opportunities as an appropriate recognition of Mr. Binger and the Robina Foundation.

Nanoscience holds the promise to result in transformative discoveries affecting nearly every aspect of human society. Funding from the Robina Foundation will help provide the infrastructure and support necessary to enable Yale researchers to play a significant role in the field by translating scientific breakthroughs into real-world applications. It is our hope that the Robina Foundation will be a partner in this important endeavor.