January 7, 2008

Dear Pat,

I am pleased to submit the following report, as part of the Doctoral Program Review, on behalf of the College of Mathematical and Physical Sciences (MAPS).

We approached this review process as an opportunity to look at the doctoral programs in MAPS afresh, forcing ourselves to look at our familiar PhD programs without bias and preconceptions. We tried to use this exercise as an instrument to spot weaknesses in our programs --- e.g., to find areas where a program’s aspirations did not match its performance or areas where insufficient investment had led to declining performance, and to identify opportunities for growth or contraction of subfields inside the core areas due to scientific advances and changing fashion, and to catalog the real strengths of our existing programs. These types of analyses, we believed, best served the spirit that prompted the Graduate School to request this review in the first place, namely the identification of doctoral programs that distinguish the Ohio State University.

As we examined the evidence about our programs, in greater and greater detail throughout the last four months, one common theme emerged: all the doctoral programs inside the MAPS College are fundamentally strong PhD programs, and have international reputations for training high-quality doctoral students in the many active scientific research areas initiated by the faculty in MAPS. There are an impressive number of world-renowned scientists who make their homes in our College. Their wide ranging research programs, dealing with some of the most exciting and promising problems on the scientific frontier today, attract students from around the world to come to Ohio State for their PhD studies. The doctoral programs in MAPS have traditionally been among the most distinguished programs inside OSU and they continue to serve as the foundation of the stature and reputation of the university.

The conclusion above is not given lightly. But the objective data about external funding of our faculty, the national rankings of the Departments in MAPS, the quality of incoming doctoral students as measured, for example, by GRE scores, and the placement of those students post-PhD all compel the conclusion. Still, there are no feelings of self-satisfaction amongst the faculty in MAPS about their doctoral programs. During the review process this Fall, each Department, led by its Vice-Chair of Graduate Studies, mercilessly dissected the flaws of its own doctoral program. And, indeed each program has weaknesses, some of which are systemic and others of a more vexing, societal nature --- the lack of qualified minority doctoral students continues to plague the PhD programs in MAPS, as it does all science doctoral programs in the US. These problems, and some proposed solutions to them, are being discussed more vigorously within the Departments as a result of this review, much more so than appear in our report to you for reasons of space.

One of the most productive consequences of this review process was the sharing of information that occurred between the doctoral programs within MAPS. This has already led to a borrowing of “best practices” between the units. For example, the issue of how to effectively collect placement information about PhD graduates is universal; the Statistics Department’s method was seen to be the most effective and is being adopted by some of the other programs.

I hope our doctoral review is informative. We would be delighted to provide further details about our doctoral programs if requested.

Sincerely yours,

Matthew S. Platz, Interim Dean of MAPS
The Doctoral Programs in the College of Mathematical and Physical Sciences (MAPS) at the Ohio State University

A report submitted to the Graduate School,

Overview

The College of Mathematical and Physical Sciences (MAPS) consists of five Departments --- Astronomy, Chemistry, Mathematics, Physics, and Statistics --- and one School with two doctoral programs --- the School of Earth Science (SES), with the Geological and Geodetic science doctoral programs. There are also two interdisciplinary graduate programs (IGPs) that are solely within MAPS --- Biostatistics and Chemical Physics. MAPS faculty are members of several other IGPs --- Environmental Science, the Ohio State Biochemistry Program, Biophysics, and Molecular, Cellular, and Developmental Biology --- which grant PhD degrees. As a convenient expression, we will sometimes call the five departments and SES the six primary units of the MAPS College below. Thus, there are thirteen separate doctoral programs inside of MAPS, which together compose the core PhD programs in the basic sciences at the Ohio State University.

The graduate programs in the six primary units vary greatly in size, from 23 in the smallest to 259 in the largest unit. The graduate programs inside of MAPS are primarily doctoral programs, in the sense that the PhD is assumed to be the goal of each entering graduate student. This assumption, however, acts more as an “open door” policy to advanced scientific study rather than an actual assumption that all entering students will earn the doctoral degree. As such, the number of true doctoral students is less than the number of graduate students enrolled in the various programs. Nevertheless, a remarkable 820 graduate students are currently enrolled in MAPS graduate programs. The PhD production amongst the thirteen doctoral programs in MAPS also varies widely. The table below shows the breakdown of PhD degrees awarded by programs, averaged over the last five years and the number of graduate students currently enrolled in the six primary units.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Astronomy</th>
<th>Chemistry</th>
<th>Mathematics</th>
<th>Physics</th>
<th>SES</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td># students</td>
<td>23</td>
<td>259</td>
<td>146</td>
<td>168</td>
<td>62</td>
<td>152</td>
</tr>
<tr>
<td>Ave. PhDs annually</td>
<td>2</td>
<td>26</td>
<td>13</td>
<td>13</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

In the basic sciences, the only indispensable factor that determines the quality of a doctoral program is the research strength of the faculty. Other factors influence the success of a PhD program, but they are ancillary. A common feature among the programs discussed in this review is the presence of an unusually strong research faculty: there are an exceptional number of discipline-leading, highly accomplished scientists within each of the six primary units of MAPS. Their ideas, international reputation, and research programs are what attract students to pursue their PhD at Ohio State. The research faculty in MAPS constitutes one of the most valuable assets of our university.

Description of assessment process

In early October 2007, the Associate Dean of MAPS met with the Vice-Chairs of Graduate Studies from each of the six primary units and requested they conduct a lengthy review of their doctoral programs along specified lines. The Vice-Chairs engaged their faculty in this process and also used the data provided by the Graduate School. After seven weeks of analysis and discussion inside the unit, each Vice-Chair submitted a five-page draft summary of their findings about their doctoral program(s) to the Associate Dean. These documents were shared amongst the Vice-Chairs for criticism. The draft process culminated in a three-hour meeting of the Vice-
Chairs and the Associate Dean. Following this, the Vice-Chairs submitted a final report on their unit. These reports were then distributed to the MAPS College leadership. The Dean and his Associate Deans met to discuss these reports over three separate sessions and arrived at the report presented here.

Explanation of the reviews

- Given the preeminence of faculty quality in a PhD program, we spend considerable space below illustrating the exceptionally high-quality research faculty in the six primary units. Among the quantitative indicators we use are the National Research Council (NRC) ranking and the total amount of external funding the faculty in a unit have been awarded, listed in the section titled \textit{Faculty Quality}.

- A commitment of the faculty to their graduate program is the second most important ingredient to a successful doctoral program. The section on \textit{Extraordinary funding or support} provides a gauge for that commitment, as it indicates both that unit’s desire to allocate their own funds (and time) to their doctoral program and the wider community’s acknowledgement of the efficacy of that program.

- High quality students are essential for a successful doctoral program. There are two sections for each unit below which contain objective information about graduate students in the different units, one with input and one with output measurements.

- Various social issues play an important role in a unit’s doctoral program. Some of these are discussed in the section titled \textit{Recruitment and diversity}.

- The review request from the Graduate School also asked for a discussion of “new or emerging opportunities” and of “competitive edge” issues for the programs be discussed. For lack of space, we confine discussion of those matters only to the programs we recommend for enhancement, in the pages following the main review.

Space considerations have forced many omissions; several plans and sub-programs within the primary units are not mentioned and numerous external honors awarded to the faculty in MAPS do not appear below.

Furthermore, the reviews below do not deal evenly with the six primary units. In order to comply with the requirement that only three of our programs could be recommended for enhancement, we have devoted more space to those three Departments and correspondingly less to the other doctoral programs.

The doctoral programs we propose for enhancement are: \textbf{Astronomy, Chemistry, and Mathematics}. We propose that the other three primary units in MAPS and the two interdisciplinary units that reside entirely in MAPS be maintained at their current levels.

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\textbf{Astronomy}

\textit{The Astronomy Department of OSU ranked 23rd, out of approximately 35 doctoral programs, in the latest (1992) NRC rankings.}

\textbf{Centrality}. The Astronomy doctoral program at OSU is small. The Astronomy Department, however, has turned this size to its advantage and created a unique, highly stimulating research environment that connects the faculty and PhD students together in an early and intimate way. This has led to a steady-stream of high quality PhDs in Astronomy from OSU who go on to academic positions around the world. Though small in number, their quality significantly increases the reputation of the Astronomy Department at Ohio State.
Relatively few undergraduates take astronomy courses at OSU: last year the Astronomy Department gave about 16,000 credit hours of instruction, including its own graduate courses. Consequently, the doctoral program in Astronomy plays only a minor role in the educational mission of Ohio State.

**Faculty quality.** The Astronomy Department at OSU is acknowledged to have one of the major university-based instrumentation groups in the US. The Department also has leading faculty members in the areas of atomic astrophysics and microlensing. In terms of NSF funding, the faculty in Astronomy garnered approximately $975K in awards last year, placing the Astronomy Department 25th among all research institutions funded by the Division of Astronomical Science at NSF.

**Student measurements (input).** Over the past five years, the average GRE scores for entering graduate students in Astronomy are: 790 on the GRE Quantitative and 570 on the GRE Verbal. Over the same period, a remarkably high 50% of entering Astronomy graduate students were awarded either a University or Dean’s Fellowship.

**Student measurements (output).** The average number of years to PhD in Astronomy at OSU, over the last ten years, is 5.5 years. This is very much smaller than the national average in Astronomy of 7.25 years and a legitimate source of pride within the Department.

Using the most recent completion rates available, approximately 76% of all entering graduate students complete their PhD in Astronomy at OSU.

The placement of PhD students in Astronomy from OSU is strong: since 1991, 97% have taken Astronomy positions in academia, with 87% of graduates have taken research postdoctoral positions. About 30% of these postdoctoral appointments are highly prestigious positions, typically going to the top 10% of new PhDs in astronomy.

**Extraordinary funding and support of the doctoral program.**

**External support.** The Department is a major partner institution in the construction of the Large Binocular Telescope (LBT). The OSU share of the cost for construction of the LBT has come from outside the Astronomy Department, primarily from the MAPS College, which has contributed over $17M to date with millions more promised. When constructed, the LBT will be one of the premier optical telescopes in the world and will be a tremendous asset to the Astronomy Department as both a research and PhD training tool.

The Astronomy Department (joint with Physics) received a TIE award for a Center in Cosmology and AstroParticle Physics (CCAPP) from Ohio State in 2006. This investment will allow distinguished scientists in both Departments to be hired, who will attract and train PhD students.

**Internal support.** This is a category where Astronomy truly excels. The faculty of the Astronomy Department have embraced their doctoral program in a remarkable way and created a program that produces PhDs 2 years sooner than the national average in the field. The foundation of this program is immersion in research. During the first two years of graduate study, OSU astronomy students complete two or three research projects, generally under the supervision of different advisors. This requires an enormous amount of “extra” time from the faculty advisors.

Morning coffee is another example of the Astronomy Department’s unusual commitment to its doctoral program. Approximately 70% of the faculty, postdocs, and graduate students meet each weekday morning for forty minutes to discuss recently posted papers in astronomy.

Order-of-Magnitude astrophysics is an innovative weekly seminar, one and a half hours per week for two quarters, required of first and second year doctoral students. The students learn how to break down complex problems and estimate their solution, sometimes in small groups, while learning mathematical analysis in the process.

Finally, the Astronomy Department devotes a higher-than-normal amount of its financial resources to its doctoral program. The average GTA stipend in Astronomy is $1,877 per month, the highest figure amongst the primary units in MAPS. The Department also provides significant
travel support and publication charges for its existing students and monetarily augments the fellowship offers to its incoming students.

**Recruitment and diversity.** 35% of current doctoral students in Astronomy at OSU are female, well above the national average of 16% across astronomy departments in the US. None of the current graduate students in the Department are of US minority origin. While the Department would be delighted to change this balance, the lack of students with this background pursuing astronomy at the undergraduate level makes this an unresolved challenge.

The Department plans to heavily use the LBT and the CCAPP initiative in their recruiting efforts in the future. The LBT, in particular, will give the Astronomy Department extraordinary leverage in recruiting and training PhD students.

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**Chemistry**

*The Chemistry Department at OSU ranked 22nd, out of approximately 170 doctoral programs, in the latest (1992) NRC rankings.*

**Centrality.** Chemistry is a fundamental science whose discoveries have fueled the explosive growth of the pharmaceutical industry, the petroleum industry, and of material sciences in general during the last one hundred years. The US chemical industry is enormous, with sales from the top ten companies alone reaching over $18T in 2006. The Ohio State Chemistry Department plays a large and important role within the research chemistry community: approximately 2% of all PhDs in Chemistry in the US during the 20th century came from OSU. The Department continues to be among the top five PhD producing chemistry departments in the country.

The Chemistry Department plays an essential role in the Ohio State educational mission: over half of all undergraduate students take a chemistry course at OSU. Last year, approximately 80,000 credit hours of instruction were given by the Chemistry Department, the vast majority of these at the undergraduate level. Most of these courses have Chemistry graduate students as TAs, and a considerable fraction of these GTAs are doctoral students. Thus, besides its research value to the Department, a robust doctoral program in Chemistry is central to the undergraduate education mission of Ohio State.

**Faculty quality.** The Chemistry Department at OSU is highly prominent within the chemistry community because of the research of its faculty. Last year, the Department garnered over $10.5M in support from outside funding agencies. Over the last ten years, external funding of the faculty in Chemistry has almost doubled. This is all the more remarkable as the number of faculty in the Chemistry Department has declined by about 12% over that same period. From the NSF alone, the Chemistry Department OSU was awarded over $4M in FY07, ranking it 7th amongst all research departments in the country by this metric.

Many members of the Chemistry Department have received distinguished, internationally recognized awards for their research. Among these faculty are: two members of the National Academy of Sciences, one member of the American Academy of Science, nine Sloan Fellows, nine NSF CAREER award winners, and two Guggenheim Fellows. Additionally, several members of the Department have received prestigious fellowships, e.g. two Beckman Young Investigator awards, one American Cancer Institute research award, and many faculty members in Chemistry have received prizes from the American Chemical Society.

**Student measurements (input).** Over the past five years, the average GRE scores for entering graduate students in Chemistry are: 710 on the GRE Quantitative and 550 on the GRE Verbal. The average GPA over the same period for entering students is slightly less than 3.5. All three numbers are considerably above the averages for graduate students at other Colleges at OSU.
**Student measurements (output).** The average number of years to PhD in Chemistry at OSU, over the last ten years, is 5.25 years. This is about average amongst Chemistry’s benchmark departments.

Using the most recent completion rates available, approximately 55% of all entering graduate students complete their PhD in Chemistry at OSU. This low rate is of concern in the Department and it has taken several steps to address this issue.

The placement data for PhD students in Chemistry at OSU, over the past ten years, is mostly anecdotal; the Department, however, plans to collect this information more systematically in the future. Nationwide, most PhDs in Chemistry go into the chemical industry, and this is true for OSU graduates also. Anecdotally, almost all the students with a PhD in Chemistry from OSU take job in either academia or industry where they utilize their advanced chemical training.

**Extraordinary funding and support of the doctoral program.**

**External support.** The Chemistry Department received a Selective Investment award from Ohio State in 1999, which was used to hire two distinguished, senior chemists. These two faculty members currently mentor multiple PhD students apiece.

The Chemistry Department at OSU leads the REEL project, an inter-university education project funded by a grant of $3.5M from the NSF. This program is designed to introduce undergraduates in chemistry to early research projects and to study ways to maintain their retention through the bachelor’s degree. The project is highly labor-intensive, for both faculty and graduate student at OSU. REEL has a significant number of current doctoral in Chemistry participating now and is expected also to attract incoming students to the Department.

**Internal support.** The Chemistry Department funds an Early Start program, offered to first year graduate students in the summer before their first Autumn in the program. Early Start provides background coursework in chemistry to the students with incomplete undergraduate training and English language practice for international students.

The average GTA salary in Chemistry is $1,673 per month, well above the norm in other Colleges across OSU. About one-third of all graduate students in Chemistry are supported as GRAs, with an average monthly stipend of $1,710.

**Recruitment and diversity.** The Department is actively addressing its lack of underrepresented minority students in its graduate program. For the past five years, it has sent faculty representatives to various minority student events, e.g. SACNS, and coordinates its efforts with Cyndi Freeman-Fail and SROP in the Graduate School. The Chemistry Department created a Diversity Recruiting and Retention Committee and also revived a local chapter of NOBCChE (National Organization of Black Chemists and Chemical Engineers). Several members of the Department are in the process of establishing scientific collaboration with Morehouse College.

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**Mathematics**

The Mathematics Department at OSU ranked 29th, out of approximately 150 doctoral programs, in the latest (1992) NRC rankings.

**Centrality.** Mathematics is the language of science, and makes the study of chemistry, physics, engineering, etc. possible. Previously discovered mathematical relationships, i.e., “old” mathematics, allow us to design before building, to predict before observing, to compute forces before they act ... and then to communicate those computations, predictions, and designs to each other and future generations. But at the current research level too, advances in pure mathematics themselves to led to spectacular breakthroughs: in medical and geophysical imaging (e.g. MRI and GPS), in modeling of biological processes including cancer growth, in channeling high-speed data flow, and in the development of digital encryption, among countless other examples.

The Mathematics Department plays a paramount role in the Ohio State educational mission: almost every OSU students take a mathematics course during their time here. Last year,
approximately 125,000 credit hours of instruction were given by the Mathematics Department, the vast majority of these at the undergraduate level. Most of these courses have Mathematics graduate students as TAs. Furthermore, serving as a GTA is considered an important part of the PhD training program in Mathematics, so all doctoral students in Mathematics serve as TAs during their time here. Thus, besides its research value to the Department, a robust doctoral program in Mathematics is vital to the undergraduate education mission of Ohio State.

**Faculty quality.** The Mathematics Department at OSU occupies a distinguished position in the mathematical community because of the research of its faculty. Two-thirds of the faculty in Mathematics are supported by outside funding agencies; the ratio of dollars per FTE in the Mathematics Department at OSU is higher than many of its benchmark peers, e.g., Michigan. Indeed, the Mathematics and Statistics Departments combined rank 6th amongst all research departments in terms of NSF dollars awarded in FY2007 through the Division of Mathematical Sciences, with about 80% of this due to the Mathematics Department. Additionally, the NSF awarded a large block grant of about $10M to the Mathematics Department in 2002 to found the Mathematical Biosciences Institute. This is one of only seven national Research Institutes in Mathematics supported by the NSF.

Many members of the Mathematics Department have received distinguished, nationally recognized awards for their research. Among these faculty are: one member of the National Academy of Science, ten Sloan Fellows, three NSF CAREER awards winners, two Guggenheim Fellows, one Waterman award winner, and eleven invited speakers to the quadrennial International Congress of Mathematicians. Additionally, the Mathematics Department counts among its members several winners of prestigious, international research prizes, including the Conant, Fermat, Fulkerson, and Polya prizes. Several sub-disciplines in the Mathematics Department at Ohio State are highly ranked, nationally, by the USNWR, including Combinatorics, ranked 7th, and Number theory, ranked 5th.

**Student measurements (input).** Over the past five years, the average GRE scores for entering graduate students in Mathematics are: 800 on the GRE Quantitative and 575 on the GRE Verbal. The average GPA over the same period for entering students is 3.7. All three numbers are considerably above the averages for graduate students at other Colleges at OSU.

**Student measurements (output).** The average number of years to PhD in Mathematics at OSU, over the last ten years, is 6.75 years. This is almost one year longer than the national average in Mathematics and is of concern within the Department.

Using the most recent completion rates available, approximately 50% of all entering graduate students complete their PhD in Mathematics at OSU. This is slightly lower than the benchmark departments in Mathematics. However, recent improvements in the program and higher Qualifying Exam passing rates indicate that a much higher completion rate, over 70%, will occur for students in the pipeline.

The placement over the past twelve years for PhD students in Mathematics from OSU is good, relative to its peer mathematics departments. During this period, over 33% of these PhDs take postdoctoral research positions at universities or institutes, over 71% take positions in some type of university, and over 97% take jobs in either academia or industry where they utilize their advanced mathematical training. A number of the postdoctoral positions taken are quite prestigious.

**Extraordinary funding and support of the doctoral program.**

**External support.** The Mathematics Department was awarded a VIGRE grant of $3.9M by the NSF in 2002. The VIGRE program’s specified aim was to increase the quantity and quality of domestic doctoral students in Mathematics. Competition for this grant was intense: the NSF made only a small number of VIGRE awards, all to traditionally strong doctoral programs. The Mathematics Department here instituted three innovative features to its graduate program via VIGRE: a Working Group Rotation requirement, the SGA program, and the Invitation to Research lecture series. Mathematics also used departmental funds to support the SGA program.
The Mathematics Department received a Selective Investment award from Ohio State in 2000, which was used to hire four distinguished, senior mathematicians in widely different fields of mathematics. Collectively, these four faculty members currently mentor over twenty PhD students.

The Mathematics Department received a TIE award in Mathematical Biology from Ohio State in 2006. Mathematical Biology is an extremely exciting area of scientific research that is still in its infancy; consequently, there are few strong programs training doctoral students in this field. The existence of the Mathematical Biosciences Institute and the new TIE funds make the Ohio State Mathematics Department poised to be the major doctoral program in Mathematical Biology in the near future.

**Internal support.** The Mathematics Department funds a Head Start program, offered to first year graduate students in the summer before their first Autumn in the program. Head Start provides background coursework in mathematics to the students with incomplete undergraduate training, training in the classroom for their upcoming TA roles, and English language practice for international students.

The average GTA salary in Mathematics is $1,845 per month, well above the norm in other Colleges across OSU.

The Department continues to fund the SGA program, started under VIGRE, out of its own funds. This program is designed to relieve PhD students from teaching at key points in their graduate careers, but is very expensive to maintain. It’s value as a retention aid and as speeding the time-to-degree for successful doctoral students is universally acknowledged within the Department.

**Recruitment and diversity.** The Department has a low number of minority students from the US in its doctoral program. However, this is bound up in the low number of domestic students in total who earn a PhD in Mathematics: less than 25% of the PhDs in Mathematics from OSU during the last five years were US citizens. Both of these problems occur nationwide in mathematics; the numbers of such students in the Ohio State Mathematics Department are consistent with its benchmark departments.

On gender diversity, the Department has made significant progress: approximately 15% of PhDs during the last five years have been awarded to women and twenty-five current doctoral students in the Department. These numbers are slightly better than the average amongst its benchmark departments.

**Physics**

*The Physics Department at OSU ranked 24th, out of approximately 150 doctoral programs, in the latest (1992) NRC rankings.*

**Centrality.** Physics is the basic science that studies matter and energy, both at the building block level and in ensembles, and how forces act on them. Theoretical physics in the last century led to a tremendous synthesis between matter and energy, demonstrating that they are actually two sides of the same coin. This synthesis has led to our greater and greater ability to manipulate energy and matter to our advantage.

The doctoral program in Physics plays an important role in the Ohio State educational mission: about one-quarter of all undergraduate students take a physics course at OSU. Last year, approximately 56,000 credit hours of instruction were given by the Physics Department, many at the undergraduate level, and most of these courses have Physics graduate students as GTAs. However, Physics supports over half of its graduate students through GRAs, so the total size of its doctoral program does not directly support the credit hours mentioned.

**Faculty quality.** The Physics Department at OSU is highly regarded in the physics research community. Last year, faculty in the Department received over $11M in support from outside
funding agencies. Over the past five years, external funding has risen by about 40%. The Department is ranked by USNRW is several subfields of physics, including a ranking of 17th in Condensed Matter physics and a ranking of 13th for Nuclear physics.

Many members of the faculty in Physics have received distinguished, internationally recognized awards for their research. Among these faculty members are one Nobel Prize winner, one member of the National Academy of Sciences, and two recent winners of major prizes given by the American Physics Society, the McGroddy and Onsager prizes.

**Student measurements (input).** Over the past five years, the average GRE scores for entering graduate students in Physics are: 780 on the GRE Quantitative and 580 on the GRE Verbal. These numbers are considerably above the averages for graduate students at other Colleges at OSU.

**Student measurements (output).** The average number of years to PhD in Physics at OSU, over the last ten years, is 6.5 years. This is about average amongst Physic’s benchmark departments.

Using the most recent completion rates available, approximately 50% of all entering graduate students complete their PhD in Physics at OSU. This rate is in line with other doctoral programs in physics nationally; nevertheless, our Department has made several modifications to its program and estimates the rate will approach 70% for students currently in the pipeline.

The placement of PhD students in Physics from OSU, over the past ten years, is consistent with its peer physics departments. About 45% of graduates during this period took university positions of some type, with about half of these positions being highly regarded postdoctoral appointments at research universities. Almost all the students with a PhD in Physics from OSU take jobs in either academia or industry where they utilize their advanced physics training.

**Extraordinary funding and support of the doctoral program.**

**External support.** The Physics Department was crucially involved in two TIE awards made by Ohio State in 2006: the Center in Cosmology and AstroParticle Physics (CCAPP), jointly with Astronomy, and the ENCOMM portion of the Advanced Materials TIE award. Both awards will fund both faculty hires that will enrich the doctoral program in Physics. The ENCOMM award, in particular, is a major investment of the university in the Department’s research and graduate educational mission.

**Internal support.** The average GTA salary in Physics is $1,815 per month, well above the norm in other Colleges across OSU. The majority of doctoral in Physics are supported as GRAs, with an average stipend of $1,827 per month.

**Recruitment and diversity.** The Department has a low number of minority students from the US in its doctoral program. This is, however, a universal problem among graduate programs in physics in this country. 14% of the students in the doctoral program currently are women, a low figure but one that is consistent with Physic’s benchmark departments.

The Department plans to use both the ENCOMM and CCAPP initiatives in their recruiting efforts in the future.

**School of Earth Sciences**

*Geosciences at OSU ranked 45th, out of approximately 100 doctoral programs, in the latest (1992) NRC rankings.*

**Centrality.** The study of geology seeks to understand how our planet works and how it developed. Research in SES at Ohio State encompasses global environmental questions about climate change, water resources, geochemistry, and polar studies. World-leading work in paleontology and geodesy are also being done by faculty in the school.

Relatively few undergraduates take geology courses at OSU: last year the School of Earth Sciences gave about 22,000 credit hours of instruction, including its own graduate courses. Some of these courses had SES graduate students as GTAs, but SES supports about two-thirds
of its graduate students as GRAs. Consequently, the doctoral program in SES plays a relatively minor role in the educational mission of Ohio State.

**Faculty quality.** Many of the faculty in SES are prolific, nationally recognized scientists within their discipline. The faculty experts in geodetic science in the School are world-renowned. SES is home to one member of the National Academy of Sciences, who has also been awarded the National Medal of Science, and numerous faculty members who have received distinguished awards for their research.

Many faculty members in SES have external funding for their research; the geodetic science group has a particularly large amount of external funding. Most research activities of the faculty in SES are multidisciplinary, as a result they are supported through many different funding agencies. In total, the SES faculty generated $5.5M in external awards last year.

**Student measurements (input).** Over the past five years, the average GRE scores for entering graduate students in SES are: 710 on the GRE Quantitative and 490 on the GRE Verbal.

**Student measurements (output).** The average number of years to PhD in SES, over the last ten years, is 6 years. This is about average amongst the geology programs that SES uses as benchmarks.

The placement of PhD students in SES from OSU, over the past thirteen years, is quite good. 67% of those students took a first position in academia and about 31% took research positions of some kind. Of those graduates, over 45% now have permanent academic positions. All of the PhD graduates from SES during this period found positions that utilize their advanced geological training.

**Extraordinary funding and support of the doctoral program.**

**External support.** The Byrd Polar Research Center (BPRC) is an internationally recognized research station and is funded by both SES and external sources. This research facility is a jewel in OSU’s crown and attracts both doctoral students and faculty to SES.

SES is a partner member of the group that received the Climate, Water, and Carbon (CWC) TIE award from Ohio State in 2006. This initiative binds together SES, BPRC, the FAES College, and the Department of Geography in an exciting, interdisciplinary program. It will serve as a major recruitment and retention tool for the doctoral program in SES.

**Internal support.** The average GTA salary in the School of Earth Science is $1,682 per month, well above the norm in other Colleges across OSU. The majority of doctoral students in SES are supported as GRAs, with an average stipend of $1,533 per month.

**Recruitment and diversity.** 39% of current SES doctoral students are female and 6% are of Hispanic origin.

**Statistics**

*The Statistics Department at OSU ranked 29th, out of approximately 65 doctoral programs, in the latest (1992) NRC rankings.*

**Centrality.** Statistics is the scientific study of patterns within large data sets, of measurements containing missing or uncertain data, and of the correlations between uniform and random variables. Applied statistics is an organizing instrument par excellence, and is the historical companion science to physics, chemistry, and biology, among others. Results in theoretical statistics allow precise inferences to be made where one has only incomplete data available. Consequently, statistics plays an increasingly important role in social studies --- e.g., political polling, economics, sociology --- in addition to its well established role in the physical sciences.

The doctoral program in Statistics plays an important role in the educational mission of Ohio State. Last year, approximately 37,000 credit hours of instruction were given by the Statistics Department and many of these courses had a doctoral student in Statistics as a TA.
Faculty quality. The Statistics Department at OSU is well regarded in both the statistics community and within the many scientific communities with which it interacts. The Department has leading experts in the dependency structure of phylogenetic trees, Bayesian modeling, and spatio-temporal statistics, among other active disciplines in statistics. The majority of the faculty members in the Department have external funding for their research, and the typical research active faculty member is engaged in several funded, inter-disciplinary projects simultaneously, often in the role of “consultant”. This makes ascertaining the total amount of external funds generated by the Statistics faculty more difficult than in other MAPS units, but we estimate that this amount about $2M from all external funding agencies. As mentioned before, the Statistics Department also makes a key contribution to the 6th place ranking of Ohio State in funding awarded from the Division of Mathematical Sciences of the NSF in FY2007.

Student measurements (input). Over the past five years, the average GRE scores for entering graduate students in Statistics are: 770 on the GRE Quantitative and 550 on the GRE Verbal. These numbers are considerably above the averages for graduate students at other Colleges at OSU. Over the same period of time, more than six students per year enrolled in the Statistics graduate program with University Fellowships.

Student measurements (output). The average number of years to PhD in Statistics, over the last ten years, is 5.5 years. This is about average amongst Statistics’ benchmark.

Determining a PhD completion rate in Statistics is difficult, more so than any unit in MAPS. This is due to the way the Department’s PhD and Masters programs intertwine, which itself is due to the attractive job opportunities available to recipients of a Masters degree in Statistics. But total PhD production in Statistics at OSU has sky-rocketed: in 2001, five PhDs were awarded and in 2007, fourteen PhDs were awarded.

The placement of PhD students in Statistics from OSU, over the past five years, is strong. About 50% of PhDs in Statistics from OSU take academic positions, which is consistent with even the strongest PhD programs in the nation. Leading pharmaceutical and financial companies regularly hire our Statistics PhDs, as do various governmental agencies.

Extraordinary funding and support of the doctoral program.

External support. The Statistics Department has a number of long-standing grants from corporations that regularly hire its PhD students. These funds are exclusively devoted to support of doctoral students in Statistics.

Internal support. The Department funds a program called STATTS, offered to first year graduate students in the summer before their first Autumn in the program. STATTS provides background coursework in statistics to the students with incomplete undergraduate training and teaching training for their upcoming roles as TAs.

The average GTA salary in Statistics is $1,834 per month, well above the norm in other Colleges across OSU. The Department also monetarily augments all incoming Fellowship offers out of its departmental funds.

Recruitment and diversity. The Department has achieved remarkable success in recruiting and retaining female doctoral students: currently, 51% of the graduate students in Statistics at OSU are female. This is the envy of all other units within MAPS and, indeed, to the wider society because of the well-known national shortage of women throughout the sciences.

The Department struggles to attract minority and non-traditional students, but continues to focus resources and attention in this direction. The Department sends faculty representatives to conferences, such as SUMSRI and StatFest, which target under-represented groups to encourage their study of statistical science.
Programs proposed for extraordinary investment of funds
The College of MAPS proposes increasing investment in three of its doctoral programs: Astronomy, Chemistry, and Mathematics. These Departments currently have high quality, internationally recognized PhD programs and further investment will certainly increase the distinction they bring to Ohio State. However, our reason for choosing these programs, over the other high quality doctoral programs in MAPS, for increased funding has additional underlying bases.

In the cases of Chemistry and Mathematics, we have central Departments whose doctoral programs form the backbone of the College (and University), both intellectually and financially. Together these two Departments teach about two-thirds of the credit hours taught from the MAPS College, thereby touching nearly every undergraduate student at OSU. The graduate students in the doctoral programs in Mathematics and Chemistry play a crucial role in this instruction while serving as GTAs. The research faculty in both Departments, who attract and train the PhD students, are highly distinguished and widely recognized for their research accomplishments by many external measurements, for example, the top 10 ranking nationally for National Science Foundation dollars in FY2007 that both enjoy within their respective Divisions at NSF. Both Departments have been heavily invested in by the central administration of Ohio State: each was given a Selective Investment award and each received a Targeted Investment in Excellence --- for Chemistry, part of the Advanced Materials TIE, and for Mathematics, the Mathematical Biosciences TIE.

But both Mathematics and Chemistry have witnessed large faculty losses and have been starved of operating funds from the MAPS College during recent years. They have maintained, even improved, their excellent doctoral programs “on the cheap” in terms of College funding. We feel that the current national ranking of these departments is not sustainable without new investment: the loss of faculty in Chemistry, and especially in Mathematics, has put the ability of these two departments to continue to attract high quality doctoral students to their programs in jeopardy. A collapse of these two core doctoral programs would be a catastrophe for Ohio State. The external reputation of OSU as a scientific research university would be irreparably damaged and because of the teaching role of these graduate students, the consequences on undergraduate education at OSU would be nothing short of disastrous. The first priority of the current MAPS College administration is to see this does not happen; the investments proposed below represent a key part of the MAPS Strategic Plan to reinvest in Chemistry and Mathematics.

In the case of Astronomy, we see a specialized doctoral program that has attained gem-like distinction. Though producing only a few PhDs, Astronomy has created an intellectual environment for its doctoral program that is the envy of MAPS. The fast time-to-PhD in Astronomy at Ohio State, which leads the astronomy community, serves to indicate the program’s special nature. We view the investments proposed here as supplementing, and being multiplied by, the large investments in the LBT and CCAPP initiatives the College has already made to Astronomy’s doctoral program.

We turn to the specific investments we propose, in reverse alphabetical order of programs.

**Mathematics**

- **Raise GTA stipends.** Measured against graduate programs at Ohio State, Mathematics supports its GTAs very well, and has done so historically. The average GTA stipend in Mathematics this year is $1,845 per month. This salary is not sufficient, however, to attract as many of the highly qualified students who apply to the doctoral program in Mathematics as desired; each year the Department loses quite a number of desirable students, to lesser ranked programs at other universities, to greater stipend offers. In
To strengthen our Mathematics Department’s graduate recruiting efforts, we propose increasing the stipend of its GTAs to market level.

- **Increase the number of students in the program.** Almost all undergraduate mathematics courses have recitation sections and almost all of these sections are taught by graduate students in Mathematics. The average recitation section size is 28. This number is too high for excellent undergraduate instruction to regularly occur. Given the central role mathematics courses play in the undergraduate educational mission at Ohio State, a highly salutary move toward quality undergraduate instruction would be to reduce the recitation section size of a typical math class. There is no *a priori* section size to aim for, although “the smaller, the better” is of course true, but it seems that a section size of 22 would produce a noticeably better outcome for the students. This lower recitation section size should not be obtained by increasing the teaching load of a doctoral student in Mathematics: an individual graduate student in Mathematics currently teaches six recitation sections per year, which is high relative to other PhD programs in the sciences; increasing this load would do irreparable damage to the PhD program in Mathematics. Instead, we propose that nineteen new GTAs be added to the Mathematics Department. At current undergraduate enrollment levels, this number of new GTAs would allow the average recitation section size to be reduced 22.

- **Support the SGA program.** Under the VIGRE grant, the Department began the Special Graduate Assignments (SGA) program. The aim of the SGA program was to give students extra time at key points in their graduate career (often while writing their thesis, but also at other junctures). These SGAs were awarded competitively and each year about fifteen SGAs were funded. This program has improved the time-to-PhD in the Department’s doctoral program and is universally heralded by the faculty. We propose to support, along with the Department, the continuation of this excellent program.

- **Fund the Headstart program.** The Headstart program has been an attractive and effective part of the Mathematics doctoral program for 20 years. It occurs in the summer, immediately before the incoming student’s fall entry into the main program, and has three components: background courses at the advanced undergraduate level designed as preparation for the Qualifying Exams, a Teacher Preparation course, and structured opportunities for international students to practice their English skills. This program was funded by the Graduate School (SGAES, then PEGS), during this time, but the College cut its support completely in 2006. We propose that funding for this valuable program be fully restored.

### Chemistry

- **Raise GTA stipends.** Measured against graduate programs at Ohio State, Chemistry supports its GTAs very well, and has done so historically. The average GTA stipend in Chemistry this year is $1,673 per month. However, as in Mathematics, this stipend is not large enough to give our Chemistry Department an advantage against programs in other universities when competing for incoming students. In order to increase our Chemistry Department’s recruiting ability, we propose increasing the stipend of its GTAs.

- **Fund Early Start.** The Early Start program has been an attractive and effective part of the Chemistry doctoral program for many years. In Early Start, the Department offers a series of courses and tutorials on topics in chemistry, designed to fill gaps from the student’s undergraduate background and prepare them for the graduate curriculum here. There are also two full-time staff members, support by the Chemistry Department, who
provide TA training and orientation to the graduate students, beginning in the Early Start program and continuing throughout the academic year. College level support for this successful program has been scaled back in recent years. We propose funding this valuable program fully in the future.

- **Support diversity programs.** The Chemistry Department has invested considerable resources, both time and money, in pursuing ways to attract more minority students to its doctoral program. Some of these ways were mentioned in the review of the program above. The College applauds Chemistry’s efforts and seeks to encourage other doctoral programs to follow Chemistry’s lead in this direction. To that end, we propose establishing a travel fund for Chemistry, to be used to offset expenses of faculty engaged in minority recruiting efforts.

- **Fellowship augmentation.** The Chemistry Department incurs significant expense by augmenting its Fellowship offers to incoming students, in order to make these offers competitive with other, outside offers these students receive. We propose sharing this expense with the Chemistry Department in the future.

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### Astronomy

- **Travel funds for observing.** Training outstanding PhD students in astronomy requires getting them to telescopes. Supporting the travel of doctoral students to telescopes is a major expense for the Department, especially because of the difficulty in obtaining grant support for this purpose. The College proposes that a travel fund be created for the express purpose of subsidizing the expenses of doctoral students in Astronomy as they travel to telescope sights.

- **Fellowship augmentation.** The Astronomy Department currently augments all of its Fellowship offers to incoming students, in order to match these offers to their GTA/GRA stipends. This is a significant expense. However, the College joins Astronomy in believing that this expense is necessary in order to make these offers competitive with other offers these students receive. We propose redirecting funds inside the College in order to share this expense with the Astronomy Department in the future.

- **Support publication costs.** The doctoral students in Astronomy are very prolific at publishing research papers while still in graduate school. Over the last twelve years, the average number of refereed papers published by an individual doctoral student in Astronomy, while still at Ohio State, is over two. This is a remarkable fact and an impressive example of the doctoral program here --- as a point of comparison, the average number of papers published by a junior tenure-track faculty member in astronomy at a research institution is 1.5 per year. There are, however, significant publication charges that the student, or his advisor, must incur. In order to encourage the continuation of this student productivity, we propose funding, or at least subsidizing, the student share of publication costs in Astronomy.

- **Raise GTA stipends.** As in the cases of Chemistry and Mathematics, the Astronomy Department supports its GTAs well. The average GTA stipend in Astronomy this year is $1,877 per month, which is the highest average within the MAPS College. Nevertheless, this stipend is not high enough to be competitive with other offers received from outside programs. In order to heighten our Astronomy Department’s ability to compete for incoming students, we propose raising the GTA stipend to its doctoral students.