A Proposal to Increase Underrepresented Student Participation in Astronomy: 
The Pre-Major in Astronomy Program (Pre-MAP)

A few months ago, we met a young woman preparing to graduate from the UW. As a child Yasmin owned a telescope and hosted star parties near her home in Eastern Washington. As a high school student she studied math and sciences; as a UW first year she loved her observational astronomy course. When we met, she had just returned from Italy, which she visited as a student in a history of astronomy class whose highlights included a visit to Galileo’s home. A better opening to the biography of a future astronomer would be hard to write. Yet Yasmin did not major in astronomy.

Yasmin’s story and others like it have made it clear to us that there are underrepresented students at the UW who, while interested and imminently qualified, are not majoring in astronomy. This represents a serious loss not only to our department, but indeed to our field. The UW is one of the nation’s foremost producers of astronomy undergraduate degrees. If we can attract these students to the astronomy major and graduate them we have a real opportunity to change the face of astronomy nationwide.

In this proposal we outline a new program, the Pre-Major in Astronomy Program (Pre-MAP), housed in our department and led by a specially selected and trained graduate student, which will target incoming underrepresented undergraduate students with a background or interest in math and sciences. By introducing these students to astronomical research early in their college careers, and by providing them with academic advising and one-on-one mentorship through their first year, Pre-MAP aims to give underrepresented students the motivation and tools to succeed in our field. Our department has stated its commitment to fixing the leaky pipeline in astronomy1, and Pre-MAP will help patch one of the local cracks.

Furthermore, participating students will develop a broad set of skills that will serve them well throughout their studies. In addition to increasing the number of underrepresented students drawn to the astronomy major, Pre-MAP hopes to address another serious problem: the high rate of attrition of underrepresented students studying math and sciences. While not every Pre-MAP student will major in astronomy, Pre-MAP will give every participant experience in successfully navigating group work and scientific problem-solving, and thereby will help develop both collaborative learning and critical thinking skills. Beyond the direct support they will receive through Pre-MAP in their first year, members of our cohort will build a peer-learning community, and will be able to call on one another for academic and emotional support throughout their undergraduate careers, alleviating some of the isolation many underrepresented students face. Although we hope that Pre-MAP students will chose to major in astronomy, we believe that all Pre-MAP participants will exit the program primed for success, whatever the field in which they decide to exercise their talents2.

In the following section we detail the structure of our proposed program. Section II describes the students Pre-MAP will target, and how we will identify and recruit them. Section III outlines the fundamental role of the graduate student who will lead Pre-MAP. Section IV addresses how we plan to assess the program, and in Section V we give the costs associated with starting Pre-MAP. We conclude in Section VI.

I. Pre-MAP: a description

Talented minorities and women abandon science as a potential major early on in their college careers. To retain these students in the sciences, and specifically to attract them to the astronomy

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major, we propose to create a special year long research and mentoring program for entering first-year students, the Pre-Major in Astronomy Program (Pre-MAP). Pre-MAP will be structured as follows:

a. A group of 15 to 20 students with an interest in math and science will be identified during the summer before they enter the UW with the assistance of programs such as Upward Bound and MESA;

b. These students will register for an Autumn quarter introductory astronomy class, and for an additional 2 credit seminar to be led by a specially trained graduate student;

c. The students will learn astronomical research techniques and tools through small group research projects designed by astronomy faculty and/or post-doctoral fellows and led by the graduate student. These projects will involve the use of cutting edge facilities and/or data available to UW students, such as the Apache Point Observatory in New Mexico or the Sloan Digital Sky Survey (SDSS) database³;

d. The students will receive one-on-one mentoring and peer support through regularly scheduled individual meetings and weekly group meetings led by the graduate student;

e. The students will continue to benefit from the mentoring relationship with the graduate student for at least the rest of the academic year, and will be encouraged to continue or expand their research project.

Other components of the program will include instruction in introductory computing for astronomical research, road trips to nearby astronomical facilities such as the UW’s Manastash Ridge Observatory near Ellensburg or the Laser Interferometer Gravitational-Wave Observatory in Richmond, and the opportunity to attend the American Astronomical Society meeting in Seattle in January 2007. In the next section we describe which students Pre-MAP will target, and how we will recruit them.

II. The targeted students
A number of programs that prepare students for the transition from high school to the UW can help us identify the target students for our proposed program. These programs include:

a. Upward Bound (UB). UB serves high school students who are minorities or who will be low income and first generation college students. Although Upward Bound is a year-round program, the main thrust of the program is a six-week mock college experience held on campus. Astronomy graduate students have taught astronomy as part of this summer program, in some cases for several years now, and we plan to build on this relationship with UB to recruit students;

b. Mathematics, Engineering, Science Achievement (MESA). MESA is involved in K-12 science outreach statewide, and its Introduction To Engineering program brings students with math and science backgrounds to the UW for two weeks during the summer. Many MESA students later enroll at the UW; this is an obvious pool from which to recruit Pre-MAP students;

c. The Minority Science and Engineering Program (MSEP). MSEP works primarily with current UW students interested in both engineering and science, but has an extensive recruiting and pre-university program. In particular, MSEP works with the Office of Admissions to identify underrepresented students who are interested in science and engineering.

Before the start of the Summer quarter, an astronomy graduate student will be selected to teach and mentor the 15 to 20 students who will make up the Pre-MAP cohort (below we describe this graduate student’s responsibilities in detail). This graduate student will then contact the programs listed above and others like them to advertise Pre-MAP, and offer to give presentations to the program directors and students about astronomy in general and Pre-MAP in particular. We

³ Appendix A is a description of one such research project, which is appropriate for introductory level students and scientifically valuable.
emphasize that recruitment will be proactive, with members of our department participating in UB, MESA, etc., events and prospective Pre-MAP students being invited to visit our department and talk to astronomy faculty, graduate students, and current majors.

III. The graduate mentor

The graduate student’s role in Pre-MAP is fundamental. He or she will be responsible for developing the content of the special Pre-MAP student seminar, as well as for coordinating the Pre-MAP research projects. Furthermore, he or she will be charged with mentoring the students academically and professionally both as a group and individually, not only for the Autumn quarter during which the students are registered in the special seminar, but for that entire academic year. This graduate student will receive significant training in preparation for this role, and will be fully supported in the development and implementation of Pre-MAP by a supervising faculty member. In exchange for this hard work the graduate student will gain invaluable experience they will apply in their own future position as a faculty member! Below we outline the graduate mentor’s responsibilities, quarter by quarter:

Summer:

a. With the assistance of the astronomy faculty, post-docs, and other graduate students, the graduate student will define small research projects suitable for introductory-level students, working in groups, to complete or to make significant progress on within the Autumn quarter. This will involve crafting tutorials introducing relevant research techniques and procedures to introductory level students;

b. As discussed above, the graduate student will identify and actively recruit a cohort of students to participate in Pre-MAP;

c. Through consultations with the relevant campus groups (CIDR, OMA, etc.), the graduate student will work on developing his or her mentoring skills, on understanding first year and underrepresented student issues, on constructing relevant assessment materials (described in Section IV), and on building a portfolio of campus resources for the selected students to call upon as needed

Autumn:

a. The graduate student will attend the weekly planning meetings for Astronomy 101 in order to keep abreast of the course content. He or she will use this information to contextualize the Pre-MAP students’ research;

b. The graduate student will lead the weekly seminars. Initial presentations and tutorials will familiarize the students with the research tools and resources needed to begin their group projects. Once the research projects are underway, the seminar will serve as a forum for addressing specific research problems and for deepening student understanding of the broader astronomical questions addressed by the research projects;

c. The graduate student will organize regular one-on-one mentoring sessions with each program participant. These meetings will address any specific difficulties encountered by the student in Astronomy 101 and during their research, the student’s experiences within the context of their research group, in addition to the student’s transition to college and first year experiences, as appropriate;

d. The graduate student will keep the faculty supervisor informed of student progress and of the program’s overall efforts. Together they will address any urgent issues;

e. The graduate student will use the assessment tools described below to evaluate the program.

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4 The summer workload described may be sufficiently demanding as to require part-time assistance from another graduate student. This assistant graduate student would then be ideally placed to take on the role of graduate mentor the following year.
Winter & Spring:

a. The graduate student will meet regularly with the Pre-MAP students to provide mentoring and academic advising to the undergraduates;
b. The graduate student will oversee any continuing research projects, developing more individualized research paths for the interested students;
c. The graduate student will help Pre-MAP participants prepare presentations of their research results for various local meetings (e.g., Mary Gates Undergraduate Research Symposium, Seattle meeting of the American Astronomical Society in Jan. 2007, etc.);
d. The graduate student will continue to facilitate and coordinate program assessments.

IV. Assessing Pre-MAP

We plan to use a number of methods to assess the effectiveness of Pre-MAP in meeting programmatic goals throughout the academic year, and suggest a number of ways of evaluating its long-term success:

Participant assessment:

The recruited undergraduate students will be surveyed at the start of the Autumn quarter to measure their expectations of Pre-MAP, their goals in participating, and their attitudes towards a career in astronomy or in the sciences. At the end of the Autumn quarter, we will ask students to comment on the usefulness of their mentoring relationship with the graduate mentor, on the appropriateness of their research project, and on their interest in this project. Finally, at the end of the academic year, we will ask them to evaluate Pre-MAP as a whole, to discuss whether it met their expectations, and to comment on whether and how it has affected their interest in astronomy or in the sciences as a major and a career.

Useful assessment will require anonymity to ensure candid responses from our (small) group of students. We will therefore work with CIDR to develop these assessment tools, to collect and interpret responses to each survey, and to incorporate appropriate changes to the mentoring relationship in order to meet the needs of our students better.

Graduate mentor assessment:

Feedback from the graduate mentor will obviously be crucial in refining the program. During the Summer quarter before the program’s start the graduate mentor and faculty supervisor will discuss how best to keep track of this feedback (for example, through a teaching diary). The graduate student will also write a report at the end of the academic year detailing lessons learned, both positive and negative, and making suggestions for the graduate student leading the following year’s program.

Further assessment:

While the self-reported information described above will provide a meaningful assessment of Pre-MAP, we believe that the participation of an outside organization such as the OMA may produce the most objective assessment of the program’s progress. We therefore hope to develop an audit system with the OMA or a similar university body to assist us in assessing Pre-MAP (possible elements could include site visits, student interviews, and review of seminar materials and research results). We look forward to discussing the best form for this audit system with the OMA.

Long-term assessment:

Two metrics could be used to evaluate Pre-MAP’s long-term success. One is obviously the number of Pre-MAP students who later major in astronomy. But Pre-MAP may also succeed in indirectly increasing the number of underrepresented students within the major: we hope that students who do not participate in Pre-MAP will be drawn to astronomy because of our efforts to make the department and the major more welcoming.

The other metric will measure the impact of the skill set provided by participation in Pre-MAP. We believe that Pre-MAP students will exit the program ready for academic success, whatever
the field in which they decide to major. To measure whether this in fact the case, we will need to know what fraction of Pre-MAP students graduate within five years and how this compares to the graduation rate of their peers and of all UW students.

V. Pre-MAP budget and sustainability

The main expense associated with Pre-MAP comes from the creation of a Teaching Assistant (TA) position to support the graduate mentor. Given the job responsibilities and program schedule outlined above, we believe that the graduate student will initially require full-time appointments during the Summer and Autumn quarters, including tuition, and a 10% supplement during the Winter and Spring quarters, in order to meet the program goals.

In estimating the following budget, we provide rough figures for the cost of the appointments, to be adjusted once tuition and pay rates for upcoming academic years are set.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Summer quarter</td>
<td>$7,500</td>
</tr>
<tr>
<td>Autumn quarter</td>
<td>$8,000</td>
</tr>
<tr>
<td>Winter and Autumn quarters</td>
<td>+$3,000</td>
</tr>
<tr>
<td>Total annual TA cost</td>
<td>$18,500</td>
</tr>
</tbody>
</table>

As described in Section I, we also anticipate that students will visit nearby astronomical research facilities and participate in local research meetings. To provide funding for these activities, we request the following:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Copy Charges</td>
<td>$100</td>
</tr>
<tr>
<td>Student Meeting registration (5 student presenters)</td>
<td>$500</td>
</tr>
<tr>
<td>Poster printing (5 student posters @ $75 per poster)</td>
<td>$375</td>
</tr>
<tr>
<td>UW vehicle rental (2 4-day trips with 2 12-person vans and 400 miles round trip)</td>
<td>$650</td>
</tr>
<tr>
<td>Lodging (5 rooms for 3 nights at $75 per night)</td>
<td>+$1,125</td>
</tr>
<tr>
<td>Total Undergraduate Research Cost</td>
<td>$2,750</td>
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</table>

Lastly, we request $500 a year to provide for cohort building activities, such as an end-of-quarter dinner and Pre-MAP t-shirts. Our total request is therefore $21,750 per year for two years, for a total of $43,500.

Pre-MAP is an innovative and potentially highly visible project. We therefore anticipate that the funding to sustain Pre-MAP beyond its first two years will be provided by a combination of departmental, college, national (NSF & NASA), and perhaps private funds. The astronomy department is committed to seeking support from relevant funding agencies and exploring all opportunities to secure long-term funding for this program. Furthermore, we anticipate that the cost of Pre-MAP will eventually be less than the amount requested here. Once the program has two cohorts under its belt, the preparatory work done during the Summer quarter will be reduced, and therefore a full Summer TA position may not be necessary.

VI. Conclusion

The Diversity Appraisal Report identified “enhancing student development and improving the educational experience of students” as one of the areas where innovative programs are needed to help the UW meet its diversity goals. We believe that the Pre-Major in Astronomy Program (Pre-MAP) will be such a program. Pre-MAP will help underrepresented students successfully manage the transition into college while increasing the chances that they will choose astronomy as a major and a career. Astronomy is full of surprises, and we cannot predict what new discoveries the future holds. But we know that we will need Yasmin’s younger brothers and sisters to help us decipher them.
Appendix A: Sample Research Project

A Serendipitous Search for Gravitationally Lensed Quasars

Prof. Scott Anderson (UW)
With Prof. Bernhard Beck-Winchatz (DePaul University), Shannon Schmoll (UW undergraduate)

Light emitted from distant luminous astronomical objects traverses extraordinary distances across the Universe before being detected by a telescope. One class of astronomical objects known as quasars, whose enormous light output arises in energy released via the accretion of matter onto a supermassive black hole, can be studied with even modestly sized telescopes out to distances exceeding 10 billion light years.

On very rare occasions on the long journey to our telescopes the light from a quasar will be bent and focused by the force of gravity of a massive object (galaxy or cluster of galaxies) that lies along the line-of-sight between the Earth and the distant quasar. The intervening massive object acts as a gravitational lens, bending the light of the quasar and sometimes producing a "mirage" of multiple, closely spaced images of the solitary quasar. Such rare, gravitationally lensed quasars are unique probes encompassing a wide range of applications in astrophysics. For example, variations in the brightness of the multiple images can be used to directly constrain the expansion parameter of the Universe, the Hubble constant. Studies of gravitational lensing also provide information on the characteristics of the lensing galaxy or cluster, such as its dark matter content.

Many of the 60 or so known gravitationally lensed quasars were found using telescopes on the surface of the Earth, and for these the spacing of the multiple images of the background quasar are relatively large. However, multiple images of lensed quasars should also occur with small angular separations, and these are easily separable in visible light mainly in images taken from space, above the blurring effects of the Earth's atmosphere. We have identified several hundred cases in which the Hubble Space Telescope (HST) has taken images of distant luminous quasars, but for reasons entirely unrelated to searching for lensed quasars. Therefore, these are, serendipitously, suitable for looking for new cases of gravitationally lensed quasars.

These HST images are easy to examine and interpret, and a UW undergraduate, Shannon Schmoll, has already demonstrated this program's viability end-to-end. The HST images are small, easily displayed with simple standard astronomical software, and readily decipherable. A good gravitational lens candidate will show multiple objects within the HST image, while those not likely to be lenses will show just a single point-like object (the image of the unlensed quasar).

Undergraduates working in small groups could examine roughly 100 HST images each, becoming the primary searchers for cases of possible new lensed quasars. They might then swap images with another group to insure that no group has missed an especially interesting case. Any interesting cases would be suitable for more intense study, first to confirm that they are newly discovered lensed quasars, and perhaps culminating in a scientific publication describing any new lens discoveries.

Associated science topics covered in the Pre-MAP seminar and in readings might include: space-based astronomical observatories such as HST; quasars and active galaxies; supermassive black holes and accretion; gravitational lensing; dark matter; and cosmology. Practical research experience gained in the team-based research would include: use of publicly accessible data archives for astronomy; display, manipulation, and interpretation of simple astronomical images; web-based searches and reading of the scientific/astronomical literature; and preparation of a scientific paper (or equivalent, even if no new cases are found).