

American Museum of Natural History
A Museum- and School-Based Teacher Residency Partnership for Preparing and Supporting
New Earth Science Teachers
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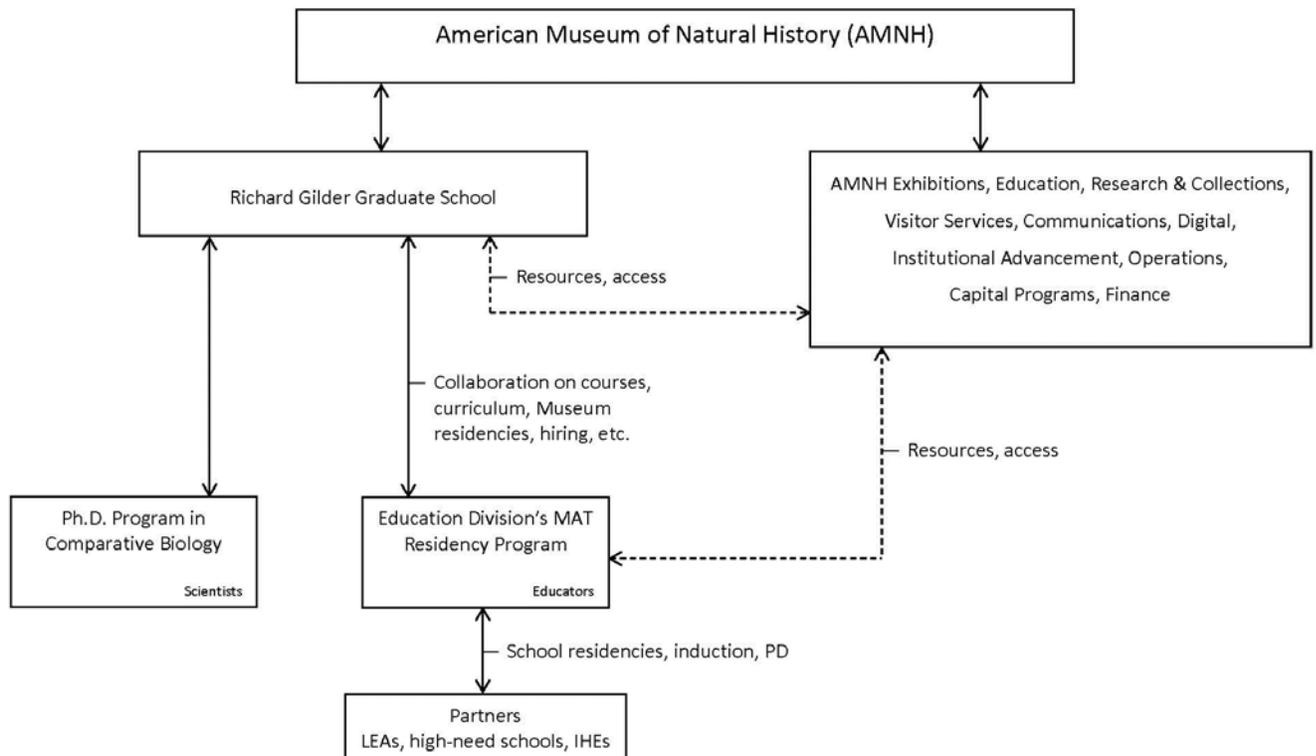
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Introduction

The American Museum of Natural History (AMNH), in partnership with the New York City Department of Education (NYCDOE) and the Center for Education Policy, Applied Research, and Evaluation (CEPARE) from the University of Southern Maine, and with the support of the New York State Education Department (NYSED), seeks TQP support under Absolute Priority #2 (Teacher Residency) and Competitive Preference Priority #1 (Promoting STEM Education), for its Masters of Arts in Teaching Residency (MAT-R) program with specialization in Secondary Earth Science, a longstanding New York shortage area. Seizing an unprecedented opportunity to transform teacher preparation in Earth science with pilot funding from New York State (NYS) in 2011, AMNH has become the only museum in the country to offer a standalone MAT program. With an average pass rate of 95.2% on all state certification exams and nearly 100% of graduates employed in high-needs schools, AMNH now seeks to build on this promise by seeking TQP support to extend its pilot program; refine its curriculum and research agenda; and expand its residency program through AY 2018–2019, thereby institutionalizing its pioneering approach to the preparation and retention of STEM teachers.

With a mission “to discover, interpret, and disseminate—through scientific research and education—knowledge about human culture, the natural world, and the universe,” AMNH has since its founding in 1869 been deeply committed to science and to public education. Part of the University of the State of New York, the Museum was chartered as an educational corporation by NYS in 1909, received authorization from the NYS Board of Regents in 2006 to grant the Ph.D. degree in Comparative Biology through its Richard Gilder Graduate School (RGGGS), and

was fully accredited by the Regents in 2009. Since as early as 1880 AMNH's Education Department has been thoroughly engaged with formal education, with offerings that include rich science-based, professional development (PD) opportunities to classroom teachers. In 2011 AMNH's Education Department was awarded a grant by NYSED to develop and pilot a clinically-rich, graduate program to prepare Earth science teachers for middle and high school, high-needs settings. Thus, under TQP regulations, AMNH serves as the partner institution, through its Graduate School, which offers the M.Phil. and Ph.D. degrees in Comparative Biology, and the Education Department's AMNH MAT-R program. Rounding out the partnership are four high-needs schools in NYC and Yonkers, NY; a collaboration with Teachers College of Columbia University; and letters of support from NYCDOE and NYSED (see Appendix G). An eligible partnership organization chart follows.



These combined AMNH resources, expertise, and capacities uniquely position the MAT-R to institutionalize an innovative and academically rigorous residency program:

- **Active scientific research enterprise.** The foundation of all AMNH endeavors is the **scientific staff** of more than 200, including more than 40 tenured and tenure-track members of the scientific faculty.
- **Expertise in graduate education in science.** AMNH has a long history in the graduate education of scientists, culminating in the 2006 founding of the now fully accredited **AMNH Richard Gilder Graduate School (RGGGS)**, which awards the M.Phil. and Ph.D. degrees in Comparative Biology, and serves as the umbrella for AMNH's broader university-level science and teacher education programs. (Under the Museum's current NYSED award, the MAT degree is being conferred by the Board of Regents through 2015; thereafter, AMNH will secure Regents authorization to grant the MAT degree directly, as it does the graduate degrees in Comparative Biology.)
- **Expertise in graduate teacher education and development.** AMNH has a longstanding commitment to teacher development in NYC and beyond, with a strong array of K–12 PD offerings both on-site and online. Through its Gottesman Center for Science Teaching and Learning, it annually reaches about 3,000 teachers.
- **A record of success working with high-needs schools,** as in the **Urban Advantage (UA)** initiative. Launched in 2004 by AMNH in collaboration with the NYCDOE and seven NYC-based, science-rich cultural institutions, UA offers PD for teachers, classroom teaching resources and equipment for schools as well as other supportive components. In AY 2013–14, UA reached 51,351 students and 514 teachers in 173 schools. Evaluation by New York University's Institute for Education and Social Policy finds that UA positively impacts

student performance on the NYS 8th grade science exam; exploratory analyses suggests the impact is largest among Asian and black students (Weinstein, et al., 2013).

- **Experience offering mentored practicum opportunities.** Since 1989, AMNH has offered a National Science Foundation (NSF)-funded **Research Experiences for Undergraduates** (REU) program, in which undergraduate students in residence at AMNH during the summer work with scientist mentors in Earth and Planetary Science, Astrophysics, and Biology to conduct scientific investigations.
- **The world’s greatest teaching “labs.”** AMNH’s world-renowned exhibition halls provide unparalleled learning environments and opportunities for teacher residents to be exposed to and study the natural world and diverse cultures.

With these outstanding resources, in 2011, with NYSED Race to the Top (RTTT) support AMNH designed and launched a pilot clinically-rich graduate-level **Earth Science Teacher Residency Program** to provide high quality teacher preparation for and licensure in Earth science, a teacher shortage area (see Appendix C). NYSED funding allowed AMNH to prepare three cohorts of residents, through August, 2015. A fourth cohort, funded by the NSF’s Robert Noyce Teacher Scholarship Program (Noyce), will graduate in August 2016. With TQP funding, AMNH would build upon this rich experience, to refine and institutionalize the MAT pilot with three additional cohorts in academic years 2016, 2017, and 2018, preparing 45 new Earth science teachers.

Significance

In response to the call for transformative approaches to recruiting, educating, and retaining STEM teachers (NAS, 2010; National Science Board, 2010; President’s Council of Advisors on Science and Technology [PCAST], 2010; National Council for Accreditation of

Teacher Education [NCATE], 2010), AMNH seeks support under the **TQP Absolute Priority #2** (Teacher Residency) and **Competitive Preference Priority #1** (Promoting STEM Education) to extend, refine, and expand the impact of and institutionalize an Earth science teacher education residency program in high-needs schools with demonstrated science teacher shortages (see Appendix A). The proposed AMNH MAT-R project builds on the pilot teacher residency, and, *for the first time*, brings together the best practices from four different teacher education and research fields: (1) Urban Teacher Residency (UTR) pre-service models in the formal education realm (Berry, Montgomery, and Snyder, 2008); (2) science learning in Informal Science Education institutions (ISEs) (Bell et al., 2009; Friedman et al. 2010; Macdonald et al., 2010); (3) high-leverage practices in science teaching (Windschitl et al, 2012; and (4) growing the practice of current teachers who serve as mentors (Hammerness, forthcoming) (See bibliography, Appendix H-1).

2(i) ...build local capacity to ... address the needs of the target population.

Developing STEM competency in middle and high school is critical to student outcomes, particularly among groups underrepresented in science such as African American and Hispanic students, English Language Learners (ELLs), and students with disabilities (e.g., NYSED, 2010). In NYS, Earth science is considered one of the “gateway” science courses to more advanced chemistry and physics and to AP-level science courses. *No Child Left Behind* requires high school students to take at least one state science exam before graduation, which in NYS is typically the Living Environment or Earth Science Regents exam. The earlier students take one of these courses and pass the state exam, the more high-level science courses they will be able to take throughout high school, increasing their chances of future success in STEM fields. The majority of high school students who pursue STEM are currently not ready to enroll and succeed

without remediation at a college, trade school, or technical school (ACT, 2010). Students who are not ready for postsecondary education are less likely to enroll in college, less likely to succeed in their college courses, and less likely to earn a college degree (ACT, 2010).

To address these issues, the AMNH MAT-R program:

- **Brings AMNH’s powerful combination of co-teaching between scientists and educators as well as its resources**—world-renowned collections, research laboratories and exhibitions—to bear in a new, more formal way on the challenge of improving science teaching, thereby pioneering a novel approach to teacher preparation and STEM education in NYS and the nation;
- **Integrates on-the-ground insights** from high-needs school leaders and teachers into teacher preparation;
- **Targets an age-range**, grades 7–12, when an interest in science can be cultivated or lost and is key to closing the achievement and graduation gaps;
- **Focuses on the teaching and learning of a set of high-leverage research-based science teaching practices**, critical for new teachers to master and central to effective student learning of key scientific concepts; and
- **Helps mentor teachers learn** alongside pre-service and new teachers within a practice school, in which all teachers at different levels of expertise learn together.

2(ii) The likelihood that the proposed project will result in system change or improvement.

In the past 15 years, efforts to improve STEM education have gained momentum with policy changes and initiatives supported in part through NSF, RTTT, and related funding. Research has consistently shown that improving teaching quality is critical to improving STEM education and achievement (NSB, 2007). Recent efforts to address the national shortage of

effective science teachers are focused on recruitment, preparation, and retention, as well as certification. In his 2011 State of the Union Address, President Obama called for preparation of 100,000 STEM teachers over the next decade, following the recommendation of his science and technology advisors (PCAST, 2010). The National Science Board (2010) recommended the development of “rigorous, research-based STEM preparation for teachers.” Finally, the *Next Generation Science Standards (NGSS)* and the educative Teacher Performance Assessment (edTPA) process both call for evidence-based learning and teaching. AMNH has been actively engaged in several of these Commissions and policy setting initiatives.

To address these issues, the AMNH MAT-R project:

- **Establishes an innovative and replicable model** for informal science education institutions to play a formal role in the preparation of teachers and **maximizes AMNH’s proven approaches** of integrating scientists and their work into science teaching;
- **Contributes to the development of NYS’s future workforce and economic competitiveness** by improving science knowledge and skills critical to 21st-century economy;
- **Prepares effective Earth Science teachers** equipped to produce significant student learning and to take advantage of formal and informal approaches to teaching and learning science;
- **Pursues a new research agenda** on the development of STEM teacher preparation partnerships that focus on how teachers learn to enact high-leverage practices in science; and
- **Informs the field** of research-based practices that can be adapted or adopted elsewhere.

2(iii) ...prepare personnel for fields in which shortages have been demonstrated.

Framed by the broad national mandate to prepare STEM teachers and as a founding partner in the 100Kin10 initiative (<http://www.100kin10.org>), the AMNH MAT-R program

specifically seeks to address the acute need for effective science teachers and the shortage of certified secondary Earth science teachers in NYS in particular (see Appendix A). As far back as 1999, the U.S. Department of Education has, with a few exceptions, steadily identified NYC, and NYS more broadly, as having a Teacher Shortage Area for Earth science (2014). The current shortage prevents many schools from offering an Earth science course, thus severely limiting students' opportunities to study this subject and prepare for the NYS Regents Examination in Earth science, or to prepare for higher education opportunities or careers in this field. To address these issues, the AMNH MAT-R program:

- **Emphasizes Earth science, a critical NY shortage area** of certified teachers;
- **Helps to produce a corps of Earth science teachers** rigorously prepared in content and pedagogy and prepared to teach and positively impact diverse students in high-needs schools;
- **Increases the number of teachers** to positively impact diverse student populations;
- **Aims to close the gaps** in achievement and graduation rates;
- **Helps improve teaching practices** of science teachers who serve as residency mentors; and
- **Seeks to increase readiness of diverse student populations** to pursue Earth science.

Project Design

AMNH and its partners seek support under the **TQP Absolute Priority #2** (Teacher Residency) and **Competitive Preference Priority #1** (Promoting STEM Education) to extend, refine, and expand the impact and approaches and to institutionalize its Earth science teacher education residency program in high-needs schools (see Appendices A and D).

Effective Teacher Residency Programs I. General

*I(a) supporting a teaching residency program, and All Eligible Partnerships requirement (e)(2)
the intended use of grant funds;*

Engaged with high-needs partnership schools throughout its MAT pilot, AMNH now proposes, in partnership with four high-needs NY schools, to extend, refine, and expand a teacher residency program that would add 45 new teachers to the cadre of nearly 70 who will already have completed the MAT, with Specialization in Earth Science, grades 7–12. To do so, the AMNH MAT-R project seeks TQP funding for these initiatives (see Appendices B and D):

- Put into place refined, revised admissions goals, evaluation, and processes;
- Implement the residency program in all its components through AY 2018–2019;
- Fully support three cohorts of residents (15 per cohort) with stipends and tuition fellowships; and
- Expand the evaluation and research plans, assessment tools, and data gathering to meet national professional educator (NGSS) and educator preparation (CAEP) standards.

I(b) Placing graduates of the teaching residency program in cohorts ...

- Place teacher residents in cohorts at high-needs host residency schools.

(c) Ensuring (1) effective pre-service preparation;

- Refine, revise, and implement curricular, assessment, and program improvements based on pilot MAT program data; and
- Provide an academically rigorous pre-service program to include pedagogy and science courses, co-taught by educators and scientists, including rich laboratory and field experiences.

I(2) Teacher mentoring

- Provide a high quality mentored residency in science, with rotations in ELL and special needs;

- Increase mentor teachers' support with release time for co-teaching, mentoring, and leadership activities and PD on high-leverage teaching practices; and
- Refine, revise, and implement mentor teacher selection goals, evaluation, and processes.

I(3) Support...through the induction program

- Provide a comprehensive induction program for two years into teaching;
- Increase induction support, in the form of stipends, etc., for participation; and
- Refine, revise, and implement induction activities to expand involvement of graduates and mentor teachers.

I(4) The preparation described in paragraphs (c)(1), (2), and (3) of Absolute Priority 1.

(c)(1) Clinical experience and interaction and (c)(2) Integrate pedagogy and classroom practice

- Implement a preparation program that includes an academic year residency with Museum teaching, science research field work, and lab experiences to deepen pedagogical content knowledge and high-leverage science teaching practices;
- Align and implement preparation with high-leverage science teaching practices; and
- Continue to develop programs that improve and enhance science instruction for students with special needs or limited English proficiency, strengthen science content knowledge, and employ effective science literacy strategies for general education teachers.

(c)(3) Provide high-quality teacher mentoring

- Provide a high-quality mentoring program; and
- Research development of capacity in residency schools and of mentors' teaching practices.

Effective Teacher Residency Programs II. Teaching Residency Programs

The AMNH MAT-R program design is built, in part, on its own wisdom-of-practice after three pilot years, the existing knowledgebase on teacher residencies and teacher leadership as

documented by the Center for Teacher Quality (Berry et al., 2008) as well as the numerous calls for innovation in recruiting, educating, and retaining STEM teachers (NAS, 2010; NCATE Blue Ribbon Panel, 2010; NSB, 2010; PCAST, 2010).

As AMNH developed the MAT-R program—and, specifically, its emphasis on co-teaching and co-leadership between scientists and educators to better teach pedagogical content knowledge—it followed the *Teachers for a New Era* design elements:

- Measuring teacher impact through student achievement;
- Collaborations between Schools of Arts and Sciences and Schools of Education; and
- Emphasis on clinical practice and induction, which is built upon close collaboration and partnership between the teacher education entity and schools.

AMNH elected to undertake Absolute Priority 2 based on encouraging reports of the advantages of clinical residencies (Berry et al., 2008; Wilson, 2009), most recently at Teachers College (in TESOL and special needs); and the extensive preparation needed for Earth science certification and to effectively teach ELL and students with disabilities.

The proposed MAT-R builds upon lessons learned as well as the **successes to date**, which include: an average 95.2% average pass rate on all NYS teacher certification exams, including 100% pass rates on the Academic Literacy Skills Test (ALST) and edTPA components; nearly 100% employment of graduates in high-needs schools (all are teaching except one temporarily out of the country); initiating the induction program; preparing and improving mentoring skills of 25 teacher mentors; and learning from the high-needs host residency schools. The logic model below lays out how TQP will be used to refine, expand, extend, and evaluate the project design and outlines the MAT-R program's inputs and resources, outputs, and outcomes/impact from AY 2014–2015 through AY 2018–2019.

American Museum of Natural History: Earth Science Teacher Preparation Program Logic Model, TQP 2014–2019

Goal: To develop and implement a highly effective residency program to meet the critical shortage area of certified Earth science teachers prepared to increase student achievement in high-needs schools throughout New York State.

Inputs/Resources	Outputs		Outcomes/Impact		
	Activities	Products	Years 1–3	Years 4–5	Post-grant
<p>AMNH & Partners: Scientists & science educators Academic programs & courses Museum mentors Visiting/guest professors Museum facilities, exhibits, objects, and classroom materials Gottesman Center for Science Teaching and Learning</p> <p>Host Residency School Partners: High-needs urban schools Administrators School mentors Other faculty & staff Programs & curricula</p>	<p>Preparation Program: Informal science education practicum, Museum- and NYC school-based teaching residency (10 months), & Museum science practicum <u>Courses (36 cr):</u> Pedagogy (18) Science (18) <u>Clinical Rotations:</u> Science, ELL, and special education <u>Mentoring:</u> School-based</p>	<p>CAEP accreditation eligible Curricula cohort based and co-taught 45 newly-certified Earth science teachers with demonstrated science and pedagogical knowledge and skills for PCK Cadre of 7–12 mentor teachers w/ completed training in teacher resident supervision Administrative policies and procedures in place w/ host residency schools</p>	<p>15 new teachers per year in project years 3–5 are effectively prepared to teach Earth science in high-needs, urban settings, and include informal science education institutions in their instruction.</p> <p>Host residency school mentors are better equipped to provide instruction in science, ELL, and for students with disabilities.</p>	<p>15 new teachers prepared, in years 4, 5 ... (see Years 1–3)</p> <p>Schools hiring AMNH-prepared teachers show increased performance in Earth science.</p> <p>New teachers successfully complete induction program, leading to increased retention.</p> <p>New teachers are rated as effective</p>	<p>A residency model of science teacher preparation and induction, serving urban school district needs is an example to others.</p> <p>Partnerships of teacher preparation providers (museum, host residency schools, and others) are robust and sustainable.</p> <p>Teachers prepared through</p>

<p>Rigorously Selected Teacher residents: Prior content knowledge Dispositions Prior experiences & beliefs</p>	<p>teachers, AMNH Earth science educators, and AMNH postdocs <u>Assessments:</u> Multiple measures of science and pedagogy knowledge and skills, including performance-based assessments Induction Program: PD workshops Mentoring Online community</p>	<p>Recruitment materials and contacts Museum faculty experienced in teacher resident development</p>	<p>Museum faculty, including scientists, are effective in providing clinically-based residency teacher preparation. Mentor teachers in host residency schools are effective partners in preparing teacher residents and strengthening schools' science instruction.</p>	<p>in teacher performance evaluations Whole school impacts (host residency schools) Employing school impacts</p>	<p>AMNH are equipped to provide instruction in schools and in out-of-school contexts. Induction Program for new teachers graduating in Years 4 and 5.</p>
<p>Evaluators: Staff Evaluation instruments Access to data</p>					

University of Southern Maine, Center for Education Policy, Applied Research, and Evaluation, Rev. 7/2014

II(a) Establishment and Design. (1) The integration of pedagogy...; and All Eligible Partnerships requirement (b) ... prepare ...teachers with strong teaching skills;

The AMNH MAT-R program is a 15-month, 36-credit teacher residency program designed for optimal effectiveness in preparing and retaining highly-effective Earth science teachers for service in high-needs schools with diverse student populations, including ELLs and students with disabilities, with a significant focus on the use of data and technology. As noted earlier, the AMNH MAT-R program follows a team-based theory and practice approach to course design, teaching, and mentoring. In addition to a full academic year of residency in high-needs public schools, the model includes two AMNH-based clinical summer field experiences (a Museum Teaching Residency prior to the school residency and a Museum Science Practicum Residency prior to entering the teaching profession). All courses are co-developed and co-taught by teams of doctoral-level educators and/or scientists. To support program participants (hereafter, residents) and strengthen retention, the AMNH MAT-R includes significant mentoring, followed by a two-year New Teacher Induction Program.

Table 1: 15-month AMNH MAT-R Program Design

Summer one (12 weeks)	Academic Year (10 months)	Summer Two (8 weeks)	Induction Years (2 years post graduation)
Courses (online and on-site) Pedagogy (16 credits) co-taught by educators Science (15 credits) co-taught by scientists and educators			PD Institutes, Workshops and Events
Museum Teaching Residency Co-teaching in youth programs (2 credits)	School Residency Rotations with MS and HS teachers of science, ELLs and students with disabilities	Museum Science Practicum Residency Field- and lab-based experience (3 credits)	
Mentoring (online and on-site) Museum team meetings (2 days/month) Online support (ongoing throughout program)			Mentoring Museum faculty meetings (monthly) and online support

This design presents the substantial complexity and challenges with the curriculum's integrated components, which the AMNH MAT-R seeks to address.

- **Summer One Museum Teaching Residency** at AMNH, in which residents co-teach in a youth science pipeline program, working with teachers experienced in school and out-of-school;
- **Pedagogy courses** co-developed and co-taught by education faculty, that focus on linking theory with practice and unique applications in the residency sites;
- **Science content courses** co-developed and co-taught by AMNH science and education faculty, including laboratory experiences designed for application in residency classrooms;
- **Academic year-long Mentored Residencies** in high-needs host residency schools, including rotations with teachers of ELLs and students with disabilities;
- **Summer Two Museum Science Laboratory and Field Work Residency** at AMNH, in which residents gain experience with authentic science research methods in the field and in laboratories under the supervision of AMNH scientists;
- **Ongoing mentoring, assessment, and support** from AMNH faculty, school mentors, and through online communities; and
- **A two-year, post-graduation New Teacher Induction Program** that fully supports graduates as they transition into their careers. The program reflects AMNH's understanding of the complexities of teaching science in high-needs schools, makes the Museum the graduates' external classroom, and seeks to reduce the high turnover rate in the first two years of teaching.

II(a)(2) Engagement in rigorous graduate-level course work leading to a master's degree...; and

All Eligible Partnerships requirement (f)(9) a year-long...clinical program component;

The year-long residency is integrated with a rigorous academic program including coursework in science and pedagogy related specifically to teaching in high-needs middle and high schools. Each of the proposed courses includes applications to the Museum and host school clinical settings to maximize development of pedagogical content knowledge. The curriculum comprises:

Summer One Museum Teaching Residency: Teaching Science in Informal Settings

(two credits): This residency, offered in tandem with the *Applied Research and Methods in Informal Science Settings* course, provides residents with insight into how informal education resources, distinctive from the school experience, can support student learning and be adapted for a variety of learning modes and for diverse urban students; and enables them to link theory to practice from the program’s start. Under mentorship of a Museum science educator, residents do this 12-week, two-credit Museum Teaching Residency in an AMNH out-of-school setting.

(f)(5).. align ... with (ii)Student academic achievement ...and academic content standards...

Academic Coursework: The development of the rigorous academic program benefitted from the framework of the *Next Generation Science Standards (NGSS Lead States 2013)*. The science content courses focus on the intersection between current scientific fields of relevance to Earth science disciplines and the content requirements of the NYS Earth Science Competency Teacher Certification Exam (CST), the edTPA for secondary science, the NYS standards for middle school and high school that pertain to Earth science (“NYS Earth Science Core Curriculum”), and NGSS. The curriculum framework includes lectures, active learning activities, laboratories, and assignments to model instruction that supports active learning. Examples of laboratory lessons developed collaboratively by MAT-R science and education faculty for use in the host residency schools include “What’s That Up In the Sky?” – Sizes and Scales of the

Universe (Astronomy), “Freezing Melts?” – Chemistry of Magma Crystallization” (Igneous rock formation), “What Makes Volcanoes Explode, (Or Not)?” – Magma Viscosity (Volcanology), and “Who Ate What?” – Interpreting Paleoenvironments From Fossil Evidence (Paleontology) (See Appendix H-6).

To ensure that the courses provide the content knowledge needed for effective teaching, content has been mapped to the NYS science curriculum and assessments, including applications for differentiated learning in host residency schools; and assignments culminate in development of middle and high school teaching units. In addition, all courses are aligned to the MAT-R Program Rubric (adapted from the NSTA Preservice Science Standards) (See Appendix H-2).

All science courses are co-taught by scientists and educators and are three credits with equivalence of 45 contact hours, with 36 contact hours face-to-face and nine contact hours in supervised classroom applications and assessments via the Rubric (see Appendix H-2). **Science courses** include:

- *Weather, Climate and Climate Change*: Components of weather; how the climate system works, what causes climate to change; past climate change, climate sensitivity today; how scientists study climate with models, observations and theory; consequences for the future.
- *Space Systems*: Fundamentals of modern astrophysics in an integrated picture that provides deep foundations for teaching the space science content in the NYS Earth Science Regents curriculum.
- *Earth Evolution and the Earth System*: Earth structure and materials, and the processes that have shaped the planet, understanding the scales of time and space over which planetary phenomena operate; the rationale of science, importance of observations, nature of evidence, and nature of scientific uncertainty.

- *Earth Science Literacy Journal Seminar*: Critical thinking skills and methodologies employed by scientists through analysis of scientific journal articles within the fields of Earth, space and climate science, along with teaching activities that support active learning.
- Depending on the distribution of their undergraduate science credits, residents are also required to complete one of the following graduate credit-bearing online science courses, either *Earth: Inside and Out* or *The Solar System*.

The pedagogy courses are taught by faculty teams that include AMNH teacher educators and part-time instructors such as literacy professors, adolescent psychologists, and education historians. **Pedagogy courses** include:

- *Literacy in Content Area with Applications to Multilingual Contexts*: Understanding how to build literacy skills and academic language that facilitate science understanding for monolingual, bilingual, multilingual, and special needs students; a required course for licensure and certification in NYS.
- *Applied Research and Methods in Informal Science Settings*: The intellectual, academic, and social roles played by cultural institutions such as museums, zoos, botanical gardens, observatories, and other outside-school environments in the lives of teachers and schools.
- *Curriculum and Instruction for Teaching Earth Science in Secondary Schools*: Analysis and critique of standards-based instructional materials to teach the NYS Core Curriculum and aligned with the National Science Education Standard (NSES), NGSS, Common Core, and contemporary educational research.
- *Developmental Variations – Development, Assessment, and Instruction with a Special Needs Focus*: School and life contexts of adolescent students, human developmental processes and

variations, including the impact of culture, heritage, socioeconomic level, personal health and safety, nutrition, and other factors that may impact a student's readiness to learn.

- *Methods and Assessments of Student Science Research*: Supporting student understanding of how science is practiced through research, use of tools and technologies, and strategies to engage students in long-term science investigations.
- *Foundations of Education in the Urban Context*: Aims to develop in secondary school science teachers the ability to analyze the importance and the acquisition of knowledge within its historical, philosophical, cultural, and social contexts and to interpret its value both within and outside of the traditional school setting.

Summer Two Museum Science Practicum Residency (three credits): Following their school residencies, residents undertake an eight-week, three-credit AMNH-based Science Practicum Residency. The practicum's goal is to develop residents' content knowledge on the practice of science, through a choice of methods that include fieldwork, laboratory investigations, and engagement with the scientific literature. After a week-long field experience exploring NYS geology and the dark night sky, residents conduct research projects in cohorts of three to five under the supervision of an RGS faculty member in the Physical Sciences and/or Paleontology Divisions and a postdoctoral fellow or senior scientist. They use state-of-the-art tools to collect and analyze Earth science or astronomical data as well as develop a related lesson plan with associated teaching materials.

In summary, to earn the MAT degree, residents must successfully complete:

- 18 credits in Education (16 of coursework, two for Summer One Museum Teaching Residency)

- 18 credits in Science (15 of coursework, three for Summer Two Museum Science Practicum Residency)
- An academic year of residencies in high-needs schools
- A digital portfolio of practice (in lieu of a thesis or comprehensive exam)
- NYS Certification Exams: (1) Content Specialty Test (CST) in Earth Science; (2) Academic Literacy Skills Test (ALST); (3) Educating All Students (EAS); and (4) The evidence-based Teacher Performance Assessment (edTPA).

II(a)(3) Experience and learning opportunities alongside a ... Mentor teacher

A hallmark of the MAT-R program is the multitiered system of support, assessment, and mentoring of the residents, who are guided by two mentors, who work closely together:

- Senior Specialists in Science and Teacher Education, who are doctoral-level science educators; and
- Residency school mentor teachers, who collaboratively selected and extensively prepared.

II(a)(3)(i) Whose teaching shall complement the residency program...; and All Eligible

Partnerships requirement (f)(8) How faculty ...work...with highly qualified teachers...

Each **Senior Specialist** co-teaches two of the required courses and mentors seven to eight residents, both in cohort groups and individually. The Senior Specialist advises the residents, offers academic support and portfolio review, and serves as field supervisor at the host residency schools. They also support the school-based teacher mentors, and during twice-monthly visits to resident's classrooms, they offer collaborative support in implementing theoretical perspectives in the classroom, improving science learning opportunities, and sharing resources.

The **teacher mentors** provide residents' with daily mentoring as well as orientation, modeling, and feedback on school norms and academic content. They utilize a co-teaching

model, integrating residents into planning, instruction, and assessment with differentiated instruction according to students' prior knowledge and needs. To ensure alignment with academic and pedagogical course content, the mentors work closely with the Senior Specialist to become familiar with the MAT-R program rubric, and attend monthly meetings to develop strategies by which the residents take progressive responsibility for teaching, implementing school-based academic assignments, and advancing their use of formative and summative assessments of student learning. Mentors also participate in role-related evaluation activities.

II(a)(3)(ii) Who shall have extra responsibilities ...

As described about induction below, AMNH MAT-R envisions an enlarged role for mentors, expanding their responsibilities beyond mentoring residents during the host residency school placements by enlisting their continued guidance and support provided through participation in an online community for graduates after they begin teaching. In addition, the program will offer all mentors the opportunity to contribute to induction planning and induction sessions.

A challenge to further expanding mentors' responsibilities is that they are often themselves still "growing" their own practice. To meet this challenge, AMNH MAT-R proposes to conduct an **assessment of mentor needs and leadership potential** during TQP project Year 1. In Year 2, the program will set goals and develop PD opportunities for mentors appropriate to their needs (including opportunities to the Museum's online science courses for teachers—Seminars on Science) and as revealed in the assessment. In Years 3–5, the program plans to work with the mentors as described above and to identify potential teacher leaders in host schools and/or as PD providers at the Museum. Mentors thus are not only "mentoring" residents through graduation and into their career launch, but also strengthening their own science teaching

practices. This development of capacity in the host residency schools will be a primary focus of the MAT-R research project described below.

II(a)(3)(iii) Who may be relieved from teaching duties....

Mentors sign an annual Memorandum of Understanding (MOU) that sets out their responsibilities and benefits (see Appendix H-3). In recognition of their additional responsibilities, mentors receive:

1. Stipend of [REDACTED]/semester, or [REDACTED] total per academic year;
2. Stipends of [REDACTED]/day for participation in six one-day mentoring workshops, for a [REDACTED] total;
3. Stipend of [REDACTED]/academic year for mentors who participate in Induction Program activities.
4. Professional one-year memberships to NSTA and TESOL;
5. AMNH family membership for one year;
6. Free registration in ongoing AMNH PD programs; and
7. Classroom assistance from the AMNH MAT-R program, including field trip planning guidance, vouchers for paid exhibitions to supplement free AMNH general admission for NYC schools.

II(a)(4) The establishment of clear criteria for the selection of mentor teachers....

Mentor selection criteria, which follow NYS requirements governing the pilot program phase, include: (1) certification in the subject he or she teaches; (2) at least three years of teaching experience; (3) deemed by his or her principal to be an exemplary teacher, (4) participation in PD and mentoring activities; (5) highly rated by AMNH science and education faculty during a classroom observation; and (6) Interest in resident mentoring and commitment to program requirements, such as progressive release of teaching responsibilities.

II(4) Evaluation of teacher effectiveness... [Note: item (v) is not applicable to this proposal]

Mentor teacher effectiveness is collaboratively evaluated selection by AMNH senior leadership and host school administrative leadership. The process includes confirming a principal's recommendation with AMNH observation of teaching. The observation rubric includes evidence of effective planning, pedagogical content knowledge, communication and questioning skills, and the use of hands-on/inquiry-based strategies.

II(a)(5) Grouping of teaching residents in cohorts...

The cohort approach is used throughout the AMNH MAT-R program, from admission through induction. Through cohort design, AMNH MAT-R seeks to encourage collaboration and to ensure that all participants see themselves as belonging to the larger professional community and the general public who are engaged and interested in science. Candidates are admitted into a cohort of 15 residents, and are put into smaller cohorts as well based on their residency school placements. To make placements, first residents visit all the partner schools and submit their placement choice along with a rationale; then AMNH faculty along with school principals and mentors make the final matches. The cohort structure is maintained in monthly school-based cohort meetings with the Senior Specialist and in monthly meetings of a school's residents and mentors as a cohort group.

Residents work in cohorts during the Summer Two Science Museum Practicum Residency's lab and fieldwork experiences, and the overall cohort structure has been retained as well during the pilot program's induction period. However, graduates have requested cross-cohort collaborative activities. With TQP funding, the Induction Program will be refined to accommodate this concern, field tested, and institutionalized.

II(a) (6) The development of admissions goals and priorities--(i) that are aligned with the hiring objectives of the LEA partnering with the program...

The decision to focus on Earth science, Competitive Preference #1, is based on the critical shortage of certified Earth science teachers in New York State and, in particular, New York City. Earth science has been a longstanding area, with shortages reported as far back as 1999 (USDOE, 2014). As of 2006–07, 6.5% of science teachers in NYS and 16.5% of science teachers in NYC were not “highly qualified”; additionally, as of 2011, the turnover rate of NYC science teachers was 6% compared with 3% for NYS—additional indicators of need (NYSED, 2011).

The shortage of certified teachers prevents many schools from offering any Earth science courses, thus diminishing students’ opportunities to study the subject, prepare for the NYS Regents exam in Earth science, graduate with a Regents degree, or be ready to pursue Earth science further. More generally, the shortage of effective science teachers negatively impacts student STEM achievement; research has consistently shown that improving the quality of teaching is critical to efforts to improve STEM education and achievement (NSB, 2007), which is key for the nation’s future workforce and competitiveness. Thus, the AMNH MAT-R program developed, in collaboration with its partners, and in response to identified NYS needs and shortage areas, these **admission goals and priorities**:

1. To recruit and admit a cohort of 15 residents in Project Years 3, 4, and 5;
2. To engage school partners in the admissions, selection, and placement processes; and
3. To diversify the STEM teaching force.

II(a)(6)(ii) consideration of individuals from underrepresented populations...

AMNH is committed to identifying, recruiting, and supporting a diverse and talented group of candidates. The selective recruitment process is designed to identify a diverse group with undergraduate science degrees (and higher), including both career changers and recent university graduates. For example, to help identify qualified applicants, AMNH partners with

campus-based student organizations and governing bodies (e.g., Black, Hispanic, Native American, Veteran, and ELL student groups) as well as the NY Urban League and NYC's Sponsors for Educational Opportunity (SEO). Recruitment efforts include extensive outreach: (1) through AMNH's existing networks; (2) to undergraduate institutions with highly ranked geoscience programs; (3) to HBCUs, majority Black colleges, as well as highly diverse colleges in the region; (4) to professional networks for minorities in STEM fields; (5) to organizations that assist underrepresented students; and (6) through publications and websites that reach diverse student populations and/or science professionals. Approximately 20% of residents in the three cohorts admitted to date have been from groups underrepresented in science education.

II(a)(7) support for residents... through an induction program...; and All Eligible Partnerships requirements (g)(3) ...design and implement an induction program..., (f)(10) and (f)(8)(i) To provide high-quality professional development activities...;

Based on research showing that beginning science teachers need support programs that address their beliefs and practices and help them build their knowledge about science and teaching science (Luft & Patterson, 2002), and that long-term, professional development endeavors have a greater impact than short-term workshops (Loucks-Horsley et al., 2010), AMNH proposes a **New Teacher Induction Program** to offer a comprehensive, coherent, and sustained PD process designed specifically to support these new science teachers and seamlessly carry them into lifelong learning and professional development (Wong, 2004). The program is offered through AMNH's Gottesman Center for Science Teaching and Learning, which is dedicated to extending Museum resources into the K–12 system in NYC and nationally through curriculum support, PD, and strategic partnerships.

The Induction Program's five goals are to: (1) improve student science achievement; (2) accelerate new teachers' effectiveness in urban classrooms; (3) increase retention of new teachers in high-needs schools; (4) develop new teachers' capacity for reflective teaching practices and leadership roles; (5) improve new teachers' expertise in incorporating informal learning experiences and museum resources into their practices (See Appendix H-4 for logic model). The program uses an iterative collaborative process for continuous improvement.

To achieve these goals, the New Teacher Induction Program takes a multi-level approach, which includes face-to-face PD at the Museum focused on curriculum support; on-site school mentoring and classroom observations to provide feedback on teaching; and an **online community** that keep graduates connected and engaged in learning from mentors. The new teachers also come together in monthly "meet-ups" with AMNH induction faculty, and induction faculty visit each new teacher every other month. In addition, the program provides six PD days at the Museum, on curriculum development, formative assessments, and assessing student work. The new teachers, as well as staff from the host residency and the employing schools, are also encouraged to attend, at no cost, an additional ten hours of PD that the Gottesman Center offers each year to NYC teachers (i.e., Election Day and Chancellor's Day programs, Educator Evenings and summer institutes). Enrollment in AMNH's online science courses for teachers is offered to mentors and new teachers as well.

All Eligible Partnerships requirements (g) (1) ... departments within the IHE are part of the induction program...

MAT-R faculty regularly cross-pollinate with the induction program through classroom visits and contributing to PD and induction activities. RGGS scientists are also available to visit induction participants' classrooms to co-teach labs and contribute to career building. For

example, an AMNH female scientist visited the Women's Leadership Academy when students indicated they didn't know that women could be scientists.

(g)(2)...the use of empirically-based practice and scientifically valid research...;

The New Teacher Induction Program is based on practice and research derived in part from the work of the New Teacher Center and AMNH's years of experience in teacher professional development. To maintain the connection with scientifically valid research and empirically-based practice, a logic model was created specifically for the development of the program that includes inputs, objectives, activities, outputs, and goals. Induction faculty meet regularly to review progress, refine goals and objectives, and share new understandings, research, and practice (See Appendix H-4).

(g)(4)... how faculty ...will be able to substantially participate...

To ensure the quality of the Induction Program, AMNH contributes the resources, expertise, and personnel of the Gottesman Center. Others, including MAT program educators and RGGS scientists, also participate, a practice that is part of normal expectation for AMNH Education Department staff and RGGS faculty. Mentors are encouraged to participate and provided a stipend.

II(b)Selection of individuals as teacher residents. (1)Eligible Individual (i); and (ii).

The preliminary eligibility criteria for application to the MAT-R program include:

- A bachelor's degree (30 credits) in Earth science (e.g., Geology, Meteorology, Oceanography, or Astronomy) OR a bachelor's degree with a minimum of 24 credits in Earth science plus six additional credits in Physics, Chemistry, Environmental Science, or Biology;

- Additional preparation that satisfies the Regents general education core requirements in the liberal arts and sciences (including credits in a foreign language—a requirement that must be fulfilled before graduation); and
- Completion of an online application that includes college transcripts and an essay.

II(b)(2) Selection Criteria. (i) Strong content knowledge

Eligible applicants submit additional application materials prior to being offered admission. To demonstrate strong content knowledge, applicants must submit transcripts demonstrating a cumulative and content area minimum GPA of 3.0. Content knowledge is also probed as part of the interview process, described in section II(b)(2)(ii) below.

II(b)(2)(ii) Strong verbal and written communication skills

Applicants who have established the minimum eligibility requirements and have provided evidence of strong content knowledge are invited for an interview conducted by a team composed of an AMNH science educator, RGGGS scientist, and school mentor or principal. Interviews probe (a) additional information reviewed by the application review including disciplinary content knowledge; (b) discussion of how the applicant would respond to school situations formulated in collaboration with residency school principals; and (c) interest in educational topics via discussion of a recent education article, which at the same time reveals verbal skills. A required essay on a pertinent educational topic demonstrates writing skills.

II(b)(2)(iii) Other attributes linked to effective teaching.

The interview process also probes other attributes by exploring an applicant's attitudes towards teaching and learning and interest in and attitude towards high-needs schools. An applicant's suitability and potential are also evaluated through the applicant's submission of three

personal references that provide additional perspective and context. Applications are reviewed by a team of education and science faculty, using specific teaching and science rubrics.

II(c) Stipends or Salaries; applications; agreements; repayments. (1); (2); (3); II(d).

Upon selection, candidates receive a letter of admission and a program support letter that details the amount and conditions of the stipend, the tuition fellowship, and other program benefits. Upon acceptance of an offer of admission, each admitted candidate must sign a program agreement including the conditions of support, the details of teaching service for at least four years at a high-needs school in NYS upon program completion, and details concerning repayment of the stipend if the program is not completed or the candidate fails to comply with the teaching service agreement. (For a Noyce-specific program agreement, see Appendix H-5. A TQP specific agreement will be created upon funding notification.)

Competitive Preference Priority 1: Promoting STEM Education

The majority of high school students who take math and science courses are not ready to enroll and succeed—without remediation—in a credit-bearing course at a two- or four-year institution, trade school, or technical school (ACT, 2010). Students who are not ready for postsecondary education are less likely to enroll in college, more likely to need remedial coursework during their first year of college, less likely to succeed in their college courses, and less likely to earn a college degree (ibid). While 35% of White high school graduates meet the ACT college readiness benchmarks for science, only 9% of African American, American Indian, and Hispanic students meet that standard. In addition, research has found that students' high school performance is best predicted by their success in middle school (Balfanz, Herzog, & MacIver, 2007; Schmidt et al., 1999). For example, higher achieving NYC 8th graders are three times more likely to graduate from high school than their lower achieving peers, and middle

school students who show signs of disengagement (e.g., course failures) are significantly less likely to graduate from high school than their more engaged peers (NYCDOE, 2008). In addition, because specialty areas are taught only in grades 7–12 and because there is an especially critical need for improved teaching—science teaching in particular—in these grades, AMNH MAT-R focuses on high-needs, diverse middle and high schools.

(1) Institutional collaboration...

AMNH MAT-R follows a team-based theory and practice approach to course design and teaching, as well as mentoring by both scientists and educators. The curriculum was developed by a cross-disciplinary faculty of tenured and doctoral-level AMNH scientists and doctoral-level educators. In addition, scientists and educators co-teach the science coursework, and educators co-teach the pedagogy coursework. Laboratory experiences include an AMNH-based Museum Teaching Residency that involves residents in teaching culturally diverse urban students under the mentorship of AMNH science educators and an AMNH-based Science Practicum Residency under the supervision of RGGGS scientists.

(2) Emphasis on hands-on and inquiry-based STEM experiences...

AMNH MAT-R emphasizes connecting theory to practice through academic year long clinical residencies in high-needs middle and high schools mentored by a highly qualified science teacher of record. Residents' teaching skills are further developed through extensive and coherent course-embedded field experiences. The AMNH MAT-R program develops teaching skills that are hands-on, minds-on practical applications of theory; high-leverage science teaching practices, such as open-ended questioning and stimulating discussions that reinforce developing scientific explanations (NGSS); writing evidence-based explanations (Common

Core); engaging in thematic, project-based, hands-on learning; and teaching with objects to determine prior knowledge and stimulate new interests.

(3) Early and multiple field-based instructional experiences...

During the first summer before the school residency begins, residents engage in a 12-week AMNH-based Museum Teaching Residency under the mentorship of AMNH science educators. In the second summer, a culminating eight-week AMNH-based Science Practicum Residency takes place under the supervision of AMNH scientists. These two Museum-based residencies, in combination with year-long school residencies and course embedded applications of content, ensure development and demonstration of pedagogical content knowledge.

All Eligible Partnerships

Many of the requirements for all eligible partnerships are addressed in the preceding pages and noted as such in italics in the appropriate section header. If not described previously, the requirements for all eligible partnerships are identified below with supportive descriptions.

(a) A needs assessment of the partners...;

Implementing this proposed high-risk but high-impact program is a considerable commitment by AMNH's Richard Gilder Graduate School and Education Department. Authorization from AMNH's Board of Trustees to pursue this novel program followed an eight-month feasibility study, AMNH staff participation in a year-long NYS Regents working group on urban teacher preparation, the encouragement of colleagues in the formal and informal education world, and the NYS Board of Regents' full authorization of AMNH's Richard Gilder Graduate School doctoral program in Comparative Biology and institutional accreditation of AMNH. In addition to the feasibility study and the needs of partner schools, AMNH MAT-R proposes to conduct a needs assessment and research project specifically directed at developing mentors' teaching skills through the use of high-leverage science teaching practices.

(c) ... prepare ... teachers to understand and use research and data...;

Professional development opportunities at AMNH are grounded in interactions with the institution's research enterprise and the "life" of the Museum itself. With pedagogical content knowledge and the scientific enterprise at the institution's core, the use of data and research is synonymous with AMNH's approach to teacher preparation. The MAT-R program includes work on the use of data to improve classroom instruction in such courses as *Curriculum and Instruction for Teaching Earth Science in Secondary Schools*, *Developmental Variations: Development, Assessment, and Instruction with a Special Needs Focus*; and *Methods and Assessment of Student Science Research*. In addition, the science content courses include the *Earth Science Literacy Journal Seminar* in which residents focus on analyzing research articles; and through the practicum and laboratory experiences, residents develop research and use data to conduct their own investigations.

The pilot program experience has revealed that teaching the use of school report card data was not successful. Some mentor teachers also were unaware of their school's data and unfamiliar with how to use it. The MAT-R program proposes, therefore, to redesign the treatment of using report card data—to partner with NYCDOE personnel to embed it in induction program sessions and in a special session for mentors and host residency school staff.

(d)(1) A description of how the program will coordinate strategies and activities...

The MAT-R program is enriched by AMNH's numerous longstanding partnerships with higher education institutions and other entities and extensive active collaborative networks. Its many integrative partnerships range from research and publication collaborations and undergraduate and graduate courses taught at the Museum, to online courses, conferences, visiting faculty, and advisory committees. In 2010, for example, AMNH edited a volume of *The*

New Educator that featured these many collaborations and AMNH and Teachers College recently signed an MOU to collaborate on induction programs.

AMNH has hosted Noyce and NYSED conferences and continues to provide leadership in convening and encouraging teacher preparation meetings, including collaborators at Bank Street College, Barnard College, Brooklyn College, City College, Columbia University, Hunter College, Lehman College, New York University, School of Visual Arts, Stony Brook University, Teachers College, and William Patterson University.

(d)(2) ... consistent with State, local, and other education reform activities...

The existing pilot AMNH MAT program, funded by NYSED and Noyce, and this proposal seeking to institutionalize its residency program as AMNH MAT-R, demonstrates AMNH's commitment to coordinating with other reform initiatives. In addition, TQP support to prepare 45 new STEM teachers will help AMNH advance the 100Kin10 initiative, of which it is a partner.

(e)(1) The integration of funds from other related sources:

AMNH has a broad base of support and a long history of successful fundraising for education initiatives, with the Gilder Graduate School as the most recent example of the Museum's success in launching and sustaining a major educational program. The MAT-R program is specifically identified as an institutional priority in AMN's 2012 Strategic Plan. In addition to funds from private sources and from the institution, other sources of funding that will be supplemented by TQP funding in 2014 and 2015 include full support for the residency program and residents stipends from NYSED in 2014, as well as residency support and stipends for residents in 2015 from Noyce.

Numerous other AMNH resources are integrated into the proposed MAT-R program as well, including: (1) experience administering graduate programs through the Graduate School ; (2) close collaboration with science faculty, senior scientist researchers, and postdoctoral scientists in the Physical Science (Earth and Planetary Science, Astrophysics) and Paleontology Divisions; (3) deep experience working with schools to improve science teaching and learning; (4) long experience offering mentored research opportunities; (5) a robust slate of on-site and online teacher PD programs that currently serve some 3,000 teachers annually; and (6) exhibitions, exhibition-related resources, classrooms, and laboratories that scaffold teacher and students use of the Museum, including world renowned science exhibition halls.

(e)(3) The commitment of the resources of the partnership...

Partner host residency school commitments: The four high-needs partner schools are (1) Archimedes Academy for Math, Science and Technology Applications (Bronx), (2) Bronx Early College Academy (Bronx), (3) Midwood High School (Brooklyn), and (4) Gorton High School (Yonkers). A sample current partnership MOU appears in Appendix G. (MOUs will be revised to include a hiring commitment for TQP.) These host residency schools commit to:

- Provide residents a mentored residency during the academic year (fall and spring semesters), including the clinical teaching opportunities required by the program’s academic courses and NYSED certification requirements;
- Include in the residency one-month rotations both with ELL and special needs teachers;
- Assign to each teacher resident a mentor, chosen by the school principal and AMNH faculty following a rigorous selection process; and
- Participate in the recruitment, selection, and host residency school cohort placement of residents.

AMNH commitments: AMNH commits its considerable resources and expertise outlined throughout the proposal. Specific to partner schools, it provides stipends for mentoring, teaching resources, and opportunities to co-teach in the program: direct services to teachers and students in the form of field trips and online resources; and the expertise and resources of its Gottesman Center for Teaching and Learning and its Gilder Graduate School.

CEPARE commitments: CEPARE brings the expertise, personnel, and resources of its evaluation experience as appropriate to its role as the program evaluator.

NYCDOE commitments: NYCDOE commits expertise and resources related to PD for teachers, Mentors, and residents.

As a supporter, NYSED also offers to facilitate program coordination, engage partners through its networks, and encourage access to resources to help advance and sustain the partnership.

(f)(1) ... how the eligible partnership will meet the purposes of the TQP grant program...

The goal of AMNH MAT-R is **to develop and implement a highly effective residency program to meet the critical shortage area of certified Earth science teachers prepared to increase student achievement in high-needs schools throughout New York State.** Table 2, below, illustrates how the program meets the TQP goals and purposes. (Shortened course titles are used.) In addition, AMNH MAT-R seeks the rigor and distinction of specialized professional accreditation through the development and implementation of a quality assurance system aligned with national standards. With TQP funding, the AMNH MAT-R program proposes to further align its residency program and formative and summative assessments with the national professional standards of CAEP, with the goal of obtaining national accreditation.

Table 2: Alignment of AMNH MAT-R Program with TQP Goals and Purposes

TQP Goals and Purposes ⇒	Absolute Priority #2	Competitive Preference #1	Improve Student Learning	Improve Teacher prep	Recruit Effective Individuals
AMNH MAT-R Program Components ⇓	√	√	√	√	√
MAT-R recruitment admissions, and selectivity					√
<i>Academic Coursework in Science</i>		√		√	
Online Science Course		√		√	
Space Systems		√	√	√	
Earth Evolution and the Earth System		√	√	√	
Weather, Climate and Climate Change		√	√	√	
Earth Science Literacy Journal Seminar		√	√	√	
<i>Academic Coursework in Pedagogy</i>					
Foundations of Education	√			√	
Developmental Variations	√		√	√	
Literacy in Content Areas	√		√	√	
Curriculum and Instruction for Teaching Earth Science	√	√	√	√	
Methods and Assessment	√	√	√	√	
Applied Research and Methods in Informal Science Settings	√	√		√	
<i>Residencies</i>					
Museum Teaching Residency	√	√	√	√	√
Academic Year Residency/Mentoring	√	√	√	√	√
Museum Science Practicum Residency	√	√	√	√	√
<i>Induction</i>					
2 years of PD/mentoring	√	√	√	√	√

(f)(6) ... prepare general education teachers to teach students with disabilities...; (f)(7) ...to teach students who are limited English proficient; and (f)(8)(ii) ... implement literacy activities...;

Science teachers at residency and employing schools will be invited to participate in ten hours of PD offered by the Gottesman Center and available to NYC teachers, including ELL and special education teachers (i.e., NYC Election Day and Chancellor’s Day programs, Educator Evenings, one- and two-day workshops, and summer institutes) and AMNH public programs offered by the Education Department (e.g., SciCafes, science and cultural film festivals, and Hayden Planetarium programs). These offerings are usually designed around a content theme with attention to modeling science practices and Common Core reading and writing strategies. Other workshops provide science teachers with resources that support topics in the science curriculum and provide strategies for engaging all students in hands-on, minds-on, and inquiry-based science. In addition, each summer the Center offers a two-week Summer Institute that provides teachers with in-depth learning in content and pedagogy, alternating each year from life science to Earth and space science. The Institute is taught by a team of AMNH scientists and science educators and includes Museum- and field-based learning experiences. Assignments, readings, and homework enhance the experience. Teachers can take the Institute as a course with graduate credit through Lehman or Brooklyn Colleges of CUNY.

Management Plan

(c) Quality of the Management Plan, (2) (i) The adequacy ... to achieve the objectives of the proposed project on time and within budget; and All Eligible Partnerships requirement (f)(2)and (a) [Note: (f)(3)is not applicable].

The project will be overseen by **Rosamond Kinzler, Ph.D.**, as Principal Investigator. A co-director of AMNH’s pilot MAT program since its inception, as PI she will have responsibility

for project oversight, for ensuring successful integration of the partners, and realization of goals. Dr. Kinzler will continue as a teaching faculty member as well.

A **collaborative project leadership team** will manage project design and implementation, induction and continued professional development, evaluation, and compliance. Meeting monthly, this team includes: **PI Kinzler**; host residency school principals; lead teaching faculty members **Denton Ebel, Ph.D.**, Curator, Department of Earth and Planetary Sciences, Professor, RGGGS, and **Mordecai-Mark Mac Low, Ph.D.**, Curator, Dept of Astrophysics, Professor, RGGGS (curator appointments are comparable to tenure and tenure track university faculty appointments); **Maritza Macdonald, Ed.D.**, co-director of the MAT pilot since its inception, who will also advise in depth on TQP program refinements during the planning and field test years; and **James Short, Ed.D.**, who will be responsible for the mentoring, induction, and PD programs. This team is supported by senior staff **Robert Steiner, Ph.D.**, who is responsible for program's use of innovative technology; and **Preeti Gupta, Ed.D.**, Director of Youth Initiatives, which is the site of the Museum Teaching Residency. The teaching faculty also includes these AMNH science educators: **Hudson Roditi, Ph.D.**, with extensive multi-lingual experience; **Elaine Howes, Ph.D.**, with extensive university-based teacher preparation experience and also on the induction staff; and the two Senior Specialists (**Julie Contino, Ed.D.**, a doctoral-level Earth science educator, and **Natasha Cooke-Nieves, Ed.D.**, a doctoral-level science curriculum specialist) who also supervise and support the residents in the four partner schools. In addition, the teaching faculty includes three senior scientists with expertise in geology, astrophysics, paleontology, and as well as postdoctoral fellows. **David L. Silvernail, Ph.D.**, Professor and Director of CEPARE, directs the external evaluation and attends Advisory Board meetings. AMNH MAT-R **project operations** are supported by the

Graduate School, whose services to the program are overseen by its Director of Administration.

An MAT-R Associate Director of Program Administration manages day-to-day operations and is supported by the MAT-R Program Assistant. Faculty participation is part of normal institutional responsibilities and workload adjustments are accommodated support participation.

Finally, as part of the institutional governance structure, an MAT-R Program Committee chaired by AMNH’s Senior Vice President of Institutional Advancement, Strategic Planning, and Education and comprising of the RGGGS Dean, PI Kinzler, and cross-divisional scientific and education teaching faculty members, will meet three times per year to address issues relating to faculty, admissions, student support and advisement, and curriculum; and securing Regents authorization for MAT degree-granting authority for the Richard Gilder Graduate School.

The proposed implementation plan is presented below in Table 3 to illustrate how the activities of the program are to be carried out, when, and by whom.

Table 3: Implementation Plan with TQP Funding Academic Years 2014 through 2018

2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	Personnel
MAT program for NYSED Cohort #3 (C3) TQP planning, revisions, and research	MAT program for Noyce C4 and TQP field test refined structures and methods	MAT-R program with 15 in TQP C5	MAT-R program for 15 in TQP C6	MAT-R program for 15 in TQP C7	Kinzler
Review and revise current host residency school partnerships	Field test revisions and methods	PD and mentoring for partner and employer schools	PD and mentoring for partner and employer schools	PD and mentoring for partner and employer schools	Kinzler Macdonald
Develop research project design	Baseline research	Implement research	Implement research	Analyze research findings	Kinzler Macdonald Hammer-ness

Evaluation redesign and CAEP process design	Field test CAEP-driven evaluation design	Implement new evaluation	Implement evaluation	Implement evaluation	Kinzler Macdonald Eldridge Silvernail
Plan program refinements and align with any ELL changes	Implement course refinements	Implement MAT-R program	Implement MAT-R program	Implement MAT-R program.	Kinzler Ebel Mac Low
Recruit, select, admit Noyce cohort	Recruit, select, admit TQP C5	Recruit, select, admit TQP C6	Recruit, select, admit TQP C7		Kinzler Ebel Mac Low
Graduate NYSED C3	Graduate Noyce C4	Graduate TQP C5	Graduate TQP C6	Graduate TQP C7	Kinzler
Induction NYSED C1 & C2; mentor assessment	Induction NYSED C2 & C3; develop mentor PD	Induction NYSED C3, Noyce C4; PD	Induction TQP C5, Noyce C6; PD	Induction TQP C5, C6 (TQP C6, C7 continues post-grant) PD	Kinzler Short

(c) (2) (ii) *The qualifications of key project personnel.*

Rosamond Kinzler, Ph.D., PI, co-director of the MAT pilot, is the Senior Director of Science Education and Director of AMNH’s National Center for Science Literacy, Education, and Technology. With a doctorate in geology from MIT, she has 15 years of experience leading science education programs and product development at AMNH for formal and informal audiences, including those supported by NASA and NSF. Kinzler previously had an active research career and co-curated the AMNH’s Gottesman Hall of Planet Earth.

Maritza B. Macdonald, Ed.D., co-director of the MAT pilot and Senior Director of Education and Policy, heads higher education partnerships and evaluation, teaches graduate courses, and works nationally on efforts that focus on formal and informal K–12 education partnerships. She has been PI on multiple NSF grants, and in 2007, served on the National Commission for 21st Century STEM Education.

James Short, Ed.D., Director of the Gottesman Center for Science Teaching and Learning, has been involved in science education for over 20 years. His professional interests include inquiry-based learning and teaching, immersive professional development, educative instructional materials, collaborations between informal science education institutions and schools, and the development of science leadership teams in schools and districts.

Mordecai-Mark Mac Low, Ph. D., Curator in the Department of Astrophysics, and RGGGS professor, is an astrophysicist with over 100 refereed papers on the formation of stars, planets, and galaxies and the structure of the interstellar medium. He has curated two AMNH digital planetarium shows and serves as an advisor to the Museum's K–12 PD programs, to UA, and to Ph.D. candidates and postdoctoral fellows.

Denton Ebel, Ph.D., Chair of the Physical Science Division, Curator-in-Charge of the Department of Earth and Planetary Sciences, and RGGGS professor, is a geologist specializing in meteorites. Dr. Ebel is a leader in combining innovative imaging techniques to obtain clues to the origin of the solar system from meteorites. He curated the AMNH's renovated Arthur Ross Hall of Meteorites and Planetary Formation, teaches and advises in AMNH PD programs, and advises undergraduates in the REU program, Ph.D. candidates, and postdoctoral fellows.

David L. Silvernail, Ph.D., Professor and Director of CEPARE, heads the external evaluation and attends advisory board meetings. He has over 25 years of research and evaluation experience using RCT and quasi-experimental designs. His work has focused on changes in teachers and their teaching practices through NSF-funded teacher development projects such as Teacher Renewal for Urban Science Teaching (TRUST) and Teachers Experience Antarctic and the Arctic (TEA).

Deborah Eldridge, Ed.D., who advises the AMNH on securing timely program accreditation, formerly served as Senior Vice President of CAEP and NCATE and as Dean, Lehman College School of Education. **Karen Hammerness, Ed.D.**, Associate Professor and Director of Research for Bard College's MAT program, consults on the research project.

Resumes of all key personnel are included in Appendix F.

(c)(2)(iii) ... performance feedback and continuous improvement...

The project is also be guided by an **external Advisory Board**, including advisors who have served since the pilot's start. Members are: Dr. O. Roger Anderson, Columbia University, Teachers College; Dr. Al Byers, NSTA; Dr. Bronwyn Bevan, Exploratorium; Dr. John Ewing, Math for America; Dr. Dave Mogk, Montana State University; Jasper Steenhuis, KIPP Academy Charter School; Dr. Suzanne M. Wilson, University of Connecticut; Dr. Mark Windschitl, University of Washington; and three MAT 2013 alumni: Duncan Blair, Secondary School for Law, Brooklyn; Sean McFadden, Eagle Academy for Young Men II, Brooklyn; and Melissa Shumer, The Young Women's Leadership School of Queens. The Advisory Board meets once annually and is consulted regularly. (See Appendix G for letters of commitment.)

In addition, the AMNH MAT-R project seeks CAEP accreditation of its residency program in 2017. Under CAEP's newly released standards and accreditation pathways, a plan for the continuous improvement of candidates and programs is a non-negotiable accreditation requirement. With support from TQP, the AMNH MAT-R intends to further refine and expand its evaluation plan, processes, and products to include a rigorous process and plan for its continuous improvement.

Program Evaluation

The MAT-R project's external evaluation is conducted by the Center for Education Policy, Applied Research and Evaluation (CEPARE) at the University of Southern Maine. CEPARE is the external evaluator for the current MAT pilot.

All eligible partnerships requirement (f)(4) The partnership's evaluation plan; and (f)(11) ... collect, analyze, and use data on retention...; and (d) Quality of the Project Evaluation (2)(ii)...methods of evaluation are thorough, feasible and appropriate...

The evaluation design is be central to determining the outputs, outcomes, and impacts of the teacher preparation program. The evaluation plan, guided by the program logic model, is designed to provide formative evaluation evidence (for program improvements) and summative evidence (measures of success and program impacts). Both quantitative and qualitative evidence are collected and analyzed, from administrative data (including GPRA and CAEP performance measures) to surveys, observations, interviews, and document analysis. This mixed-method approach enables the evaluators to document the complexities of the project, triangulate the evaluation evidence, provide useable and appropriate feedback to the project staff on a timely basis, and provide evidence to the funding agency.

Formative Evaluation Activities (d) Quality of the Project Evaluation (2) (iii) ...performance feedback and permit periodic assessment of progress toward achieving intended outcomes.

The TQP funding will be used to review and revise several teacher preparation program elements; timely and ongoing feedback is critical to informing the iterative revision process. Because summative data on resident and student outcomes will take time to materialize, the evaluation plan contains multiple ways of gathering information to suggest whether program adjustments are working as intended. These include:

- a) Surveys of residents, graduates, and mentor teachers at mid-year and end-of year, and surveys of other stakeholders (faculty, school administrators, etc.) annually, to elicit feedback and gauge partner involvement in program activities.
- b) Detailed resident course evaluations.
- c) Observation of selected project activities (monthly faculty meetings, MAT courses, partner school visits, induction activities, mentor teacher trainings).
- d) Interviews and focus groups with project staff, faculty, program and institutional administrative staff and program residents and graduates.
- e) Document analysis (course syllabi, curriculum documents, policy manuals, minutes)

Feedback will be provided to the program leadership on an ongoing basis, including written summaries of each survey activity and quarterly meetings with program leadership to discuss other emerging findings, and via formal annual reports.

Summative Evaluation Activities: Outputs, Outcomes, & Impacts (d) Quality of the Project Evaluation (2)(i)... methods of evaluation provide valid and reliable performance data.

The summative evaluation entails the collection, analysis, and reporting of outcome and impact evidence. Program outputs capture measures in accordance with GPRA, Title II, and HEA Section 204(a), and also meet CAEP annual reporting requirements. These data points include performance on state-required certification exams, academic performance, retention and completion rates, and resident self-report of preparedness. Additional data collection and analysis investigate program outcomes by capturing performance-based data on graduates. Table 4 below lists the summative evaluation strategies and measures:

Table 4: AMNH MAT-R Summative Evaluation Strategies and Measures

Measure	Report/Type	Year 1 Planning	Year 2 Pilot	Year 3 TOP 5	Year 4 TOP 6	Year 5 TOP 7
Program Outputs & Implementation Measures						
NYSED Cert. Exam Results (Completers & other enrolled) [Earth Science CST, ALST, EAS, and EdTPA]; comparison to other Earth science completers & to baseline	GPRA 4(a)(1) & 4(c); Title II; HEA 204(a), (i) & (iii); CAEP		Pilot	X	X	X
Average GPAs at admission & completion, MAT Faculty observation scores, and mentor teachers' ratings [AMNH MAT Rubric]	CAEP	X	X	X	X	X
Program retention/completion rate	GPRA 4(a)(1) & 4(e)(1); CAEP	X	X	X	X	X
# & % Obtaining NYS certification	GPRA 4(a)(1), Title II, CAEP	X	X	X	X	X
Measure	Report/Type	Year 1 Planning	Year 2 Pilot	Year 3 TOP 1	Year 4 TOP 2	Year 5 TOP 3
% of teachers trained in technology/UDL and use of data to inform teaching & learning	HEA 204(a), (d)(7)(i-ii)		Pilot	X	X	X
Program Completer Survey: program satisfaction, preparedness, ongoing needs	CAEP	X	X	X	X	X
Program Outcomes Measures						
Teacher evaluation ratings of graduates employed in NYS	GPRA 4(d)		Pilot	X	X	X
Earth Science Regents performance in graduates' schools	GPRA 4(d)	Base line	X	X	X	X
Job placement rate (high-needs LEA & overall)	GPRA 4(e)(2); CAEP	X	X	X	X	X
% HQT hired in LEA; # from underrepresented groups, high-needs subjects & areas; elem. & secondary	HEA 204(a), (d)(1 to 5)		Pilot	X	X	X
Employment retention rate, 1 & 3 year	GPRA 4(b), 4(d), 4(e)(2); HEA 204(a), (ii);CAEP	1 yr	1yr	1yr	1yr	1, 3 yr
Employer surveys	CAEP		Pilot	X	X	X
Compare class observation ratings at end of 1 st and 2 nd year of teaching to pre-service performance (using MAT Rubric)	CAEP		Pilot	1 st yr	1 st , 2 nd yr	1 st , 2 nd yr

Program outcomes will be measured in multiple ways. First, to assess the impact of program graduates on student learning (GPRA Performance Measure 4(d) and CAEP Standard 4: Program Impact requirements), the evaluation plan will adopt a two-pronged approach. For the majority of graduates who will secure employment in a NYS high-needs school, the current Annual Professional Performance Review (APPR) system in place for all NY public school teachers will provide an annual rating of effectiveness. These ratings will be collected for all program graduates teaching in NY schools, and the average combined rating of each TQP cohort and of the three TQP cohorts combined (approximately 45 teachers) can be compared to the average ratings of other science teachers across NYC and the state. The NYS APPR system bases 40% of the teacher ratings on measures of student learning, using both state and locally determined student assessments.

In addition, because of NYS's long-standing history with its Regents program, data will be readily available on overall student performance (pass rates and average scale scores) on Earth Science Regents exams in the secondary schools where TQP graduates are hired to teach the Regents-level course. School-wide Earth Science Regents performance in the graduates' second year of teaching will be compared with those schools' average performance in the two years prior to their hire; paired comparison analysis will indicate whether the beginning teachers had an aggregate significant influence on student Earth science achievement in their high-needs schools, and the effect size of any impact. Using each school's historic data as comparison provides strong internal controls. This method will capture net impact on the high-needs schools; AMNH program graduates to date are almost always the sole teacher of Regents-level Earth Science courses, reducing the potential influence of other teachers' skill level on the student

achievement levels. Any effects will be moderated by the skill and experience of the teachers in the baseline comparison years.

In other analyses of graduate performance, the evaluation will also assess the impact of the TQP partnership on the LEA's teacher workforce, both by tracking job placement and retention of program graduates and by reporting improvements in the HQT status of the science teachers in the employing schools, compared to baseline two-year averages prior to hiring.

Lastly, the program has the capacity to investigate the performance growth of its graduates in the initial two years of teaching by extending the use of the AMNH Observation Rubric into the induction years. Residents are rated on several performance indicators during their pre-service residency; those who secure employment in schools in greater NYC also receive periodic school visits from AMNH faculty during their first two years of teaching. During the planning year, educators providing induction support will be trained in the use of the AMNH Observation Rubric so that they may assess the performance of the beginning teachers using the same scales. Aggregate performance of each cohort of graduates on each indicator will be compared to their end-of-residency ratings to determine areas where they have the most and least growth in their induction years. Once three cohorts of data are available, subgroup analysis will assess whether beginning teacher growth is related to characteristics such as exit GPA, performance on state certification assessments, level of participation in AMNH-provided induction supports, and self-reported level of induction support provided by employing schools.

The NYS teacher certification examinations and Earth Science Regents examinations used in these analyses were developed and tested by Pearson and have well-documented validity and reliability (NYSTCE, 2013; NYSED, 2012). The edTPA assessment developed by Stanford researchers has been studied and thoroughly piloted, and also has documented validity and

reliability results (SCALE, 2013). The AMNH Observation Rubric was developed by the program and informed heavily by Charlotte Danielson's Framework for Teaching and NSTA's pre-service teacher evaluation rubric; the faculty using the rubric engaged in several sessions of group norming to establish inter-rater reliability, using videotapes and discussions of their individual practices when piloting the instrument with the initial AMNH MAT cohorts.

Monitoring Role (d) Quality of the Project Evaluation and (2) (iii).

In addition to the formative and summative data collection and analysis described above, the evaluation team will also play a monitoring role. Evaluators will use all of the above data to capture descriptive information about program implementation and enable external assurances to the funding agency that the project is implemented as proposed. Specifically, evaluators will monitor these elements of particular interest to the TQP goals and to CAEP accreditation:

- a) Implementation of ongoing academic progress monitoring through the AMNH resident advisory system, including mid-year and end-of-year team review;
- b) Nature and extent of partner involvement (school administrators and mentor teachers) in resident selection, resident evaluation, and input into ongoing program refinements;
- c) Processes for Evaluating mentor teacher quality, including mentor selection criteria, monitoring participation in PD, faculty feedback on mentor effectiveness, and systems for retaining or replacing mentors.

The Proposed Research Project

Although not required by TQP nor part of the formal evaluation plan conducted by CEPARE, AMNH recognizes that high-quality research on "what works" in teacher preparation is sorely needed by the field of education. Currently, with NSF funding, an MAT-related research project is collecting and analyzing data on the teaching effectiveness of residency-

prepared Earth science teachers compared with other Earth science teachers. Test results from 2014 on the first year teaching of 2013 graduates and on the second year of teaching from 2012 graduates will be analyzed and available in 2015. With that ongoing research project and its commitment to research overall, AMNH MAT-R proposes to develop a research project focused on further understanding, in a scientifically responsible manner, the development of host residency schools into true partner schools in which a shared vision and mutual accountability for the success of K–12 students and the preparation of new teachers is a common commitment.

Thus, the goals of the proposed AMNH MAT-R research project are to plan and collect baseline data, field test methods, create common interest among partners, and implement a three-year research study. Year 1, the planning year, begins to develop relationships and work with key stakeholders in school sites. It focuses on putting into place the structures (course structures and residency arrangements, as well as release time for teachers), as well as the specific activities and curriculum for the induction and mentor teachers that both parallels and intersects with the curriculum for the residents) that allows for deep learning and enactment of these high leverage teaching practices in science. Simultaneously the year's work involves fine-tuning the research design, focusing the research questions, identifying specific methods, and field-testing instruments for examining the development work. In Year 2, the structures for engaging with and supporting the host residency school sites are piloted and initial data are collected. In Year 3, the work is finalized, the research is fully engaged, and data are analyzed to examine mentors', pre-service teachers', and graduates' work through Years 4 and 5.