American Museum of Natural History
A Partnership to Support a Museum- and School-Based Teaching Residency for Earth Science Teachers

Introduction

The American Museum of Natural History (AMNH), in partnership with the four district superintendents of high-need schools in Yonkers (Roosevelt High School), Queens (Hunters Point Community Middle School), Brooklyn (Sunset Park High School), and the Bronx (Highbridge Green Middle School), seeks TQP support under **Absolute Priority** (Partnership Grants for the Establishment of Effective Teacher Residency Programs) and **Competitive Preference Priority #1** (Prepare Educators to Deliver Rigorous Instruction in Computer Science and Improve Student Achievement) for the expansion of its Master of Arts in Teaching - Residency (MAT-R) program with specialization in Secondary Earth Science, a longstanding New York State (NYS) shortage area. With an average final pass rate of 100 percent on all state certification exams and a 100 percent hiring rate in high-need schools for all graduates that seek employment, AMNH now aims to build on its record of success by seeking Teacher Quality Partnership (TQP) support to:

- Expand the MAT-R program from cohorts of 15 residents each year to cohorts of 24 residents each year to prepare and graduate 72 new Earth science teachers through academic year (AY) 2023–2024;
- Refine program supports to ensure integration of culturally responsive science teaching practices in the courses, teacher identity workshops, and residency placements to ensure that **all** students have access to quality learning opportunities regardless of gender, race, ethnicity, or first language; and
- Integrate computational thinking (CT) into the MAT-R curriculum through a collaboration with an external consultant with expertise in CT-integrated curricula.

Since its founding in 1869, AMNH has been deeply committed to science and public education with a mission "to discover, interpret, and disseminate—through scientific research and education—knowledge about human culture, the natural world, and the universe." As part of the University of the State of New York, AMNH 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 (RGGS), and was fully accredited by the Regents in 2009. In 2012, AMNH piloted its MAT-R program, funded in part by the New York State Education Department (NYSED) and National Science Foundation (NSF) Discovery Research PreK-12 (DRK-12) program. The MAT-R program has since been formalized, sustained, and refined through 2011 and 2013 NSF Noyce grants. With prior TQP funding, AMNH built upon this rich experience with three additional cohorts in AY 2016, 2017, and 2018, and the program has prepared a total of 94 Earth science teachers. The program received recognition from the National Science Teachers Association in 2017 and accreditation from the Council for the Accreditation of Educator Preparation (CAEP) in 2019. AMNH is the only museum in the western hemisphere to offer a standalone MAT degree program.

Adequacy of Resources: AMNH expertise and capacity uniquely positions the MAT-R program to leverage existing resources and expand its innovative and academically rigorous residency program: **Active scientific research enterprise -** the foundation of all AMNH endeavors is the **scientific staff** of over 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 fully accredited **AMNH RGGS,** 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. **Expertise in graduate teacher education and development -** AMNH has a longstanding commitment to teacher development in New York City (NYC) and beyond, with robust K–12 professional development (PD) offerings on-site and online. Through its Gottesman Center for Science Teaching and Learning, it annually reaches about 3,000 teachers. **Scholarship and research on teaching and teacher education** - AMNH educators are actively engaged in research on teaching, teacher education, and science education, including in active inquiry into the MAT-R program (Fallona, Doykos, Howes, Trowbridge, & Wallace, 2018; Habig, Gupta, & Adams, 2018; Hammerness & Kennedy, 2018) with MAT-R graduates as authors (e.g., MacDonald, Silvernail, Cooke-Nieves, Locke, Fabris, Biene, Passow, 2018). **A record of success working with high-need schools, as in the Urban Advantage (UA) initiative** - launched in 2004 by AMNH in collaboration with the NYC Department of Education (DOE) and seven NYC-based, science-rich cultural institutions (Hammerness, MacPherson, Roditi, Macdonald, & Curtis-Bey, 2017). Since its inception, UA has served over 395,000 students and their families and 2,037 teachers at 457 schools. Evaluation by New York University's Institute for Education and Social Policy consistently finds that UA positively impacts student performance on the NYS 8th grade science exam (Weinstein et al., 2019). **Experience offering mentored practicum opportunities** - since 1989, AMNH has offered a NSF-funded Research Experiences for Undergraduates (REU) program with AMNH scientific staff. **An institution-wide focus on diversity and equity -** in 2018, the Board of Trustees adopted a statement reflecting AMNH's approach to diversity, equity, and inclusion (DEI), and the institution has engaged in designing a comprehensive DEI work plan that addresses the full spectrum of the Museum's operations and activities with specific actions and measurable outcomes. Part of this effort includes designing and offering a set of learning experiences,

informed by the deepening practice of the MAT-R faculty, for all AMNH Education staff with a focus on foundational research principles undergirding culturally responsive teaching (CRT) and an initial repertoire of CRT practices. **Dynamic and innovative public education engagement -** AMNH's world-renowned exhibition halls provide unparalleled learning environments for residents to be exposed to and study the natural world and diverse cultures.

This request for TQP funding would graduate an **additional 72 new Earth science teachers** for high-need schools. Specifically, program refinements will focus on: 1) explicit articulation of and support for CRT in coursework, the residency experience, and the development of teacher identity with the goal of deepening program practices for teaching residents about CRT practices; 2) supporting residents, mentors, and graduates to integrate CT into their science lessons; 3) collaborating with the superintendents from Queens, Brooklyn, Bronx, and Yonkers to identify new high-need schools to partner with as residency schools; 4) broadening strategies to bolster the annual recruitment of a diverse, committed corps of residents from cohorts of 15 to the proposed cohort size of 24; and 5) supporting retention through further incorporation of mentoring of new teachers by experienced MAT-R program graduates.

Significance

Developing STEM competency in high school is critical to student outcomes, including among groups underrepresented in science, such as Black and Latinx students, English language learners (ELL), and students with special needs (PCAST, 2012; NRC, 2011). Yet recent data suggests that only one-third of teachers teaching science in NYS are prepared to teach their subject area (Gais, Backstrom, Malatras & Park, 2018), and 31 percent of Earth science teachers in NYC are not certified to teach in their subject area (NYSED, 2012). Nationally, most states identify severe shortages in special education, followed by math and science (Sutcher, 2016).

The current shortage of Earth science teachers (USDOE, 2017) prevents many schools from offering any Earth science courses, severely limiting students' opportunities to accumulate credits required to graduate or prepare for higher education opportunities or careers in STEM fields. Increasing the number of middle and high school teachers who can positively impact student populations, especially in complex, urban classrooms with diverse learners, will be central to closing the achievement and graduation rate gaps and to increase diversity in science professions (National Science Board, 2007).

Research on the AMNH MAT-R program has consistently found that the program is making gains in providing more access to science exams and demonstrating impact on students' test scores, albeit under challenging circumstances (Weinstein & Barthel, 2019). Studies of AMNH MAT-R graduates who are teaching in NYC find that they are consistently teaching a higher percentage of poor, Black, and Latinx students and lower percentages of Asian and white students than their counterparts citywide. Still, a *larger percentage* of students of MAT-R graduates continue to take the Earth Science Regents each year compared to students taught by comparison group teachers. (Students in NYS are required to pass one science Regents exam to earn their high school diploma in any of the four high school science disciplines: Earth science, biology, chemistry, or physics. Earth science is considered the entry-level discipline; however, many schools do not focus on it because of the lack of well-qualified Earth science teachers.) Furthermore, though MAT-R graduates' students are higher-need than their peers' students, *their students do as well and in some cases are outperforming the students in classrooms taught by non-AMNH MAT-R teachers* (Weinstein & Barthel, 2019). In addition, MAT-R graduates are remaining in high-need settings: of the 94 MAT-R graduates, 80 are currently teaching (about 85 percent). Studies of national teacher retention find that 20-30 percent of teachers leave the

profession within the first five years (70-80 percent retention rate), and attrition is even higher from high-need schools and teacher shortage areas.

Studies suggest that strong teacher preparation helps increase teacher efficacy and ensure they stay in teaching longer (Sutcher et al., 2016; Podolsky et al., 2016). In addition, research on the nature of strong teacher preparation suggests that providing prospective teachers with opportunities to rehearse, simulate, and enact specific teaching practices is particularly important (Ball & Forzani, 2009; Grossman et al., 2009, Feiman-Nemser, 2001). In the last decade, much of the development in science teacher education has focused on increasing understanding of the role of teaching *practices,* based on evidence of student learning, and how to help new teachers adopt those practices (Ball & Cohen, 1999; Lampert et al., 2013; Fogo, 2014; Forzani, 2014; Kloser, 2014; Windschitl, Thompson, Braaten & Stroupe, 2012). However, scholars are still working to understand what form these practices should take for diverse learners, including ELL and children with special needs, and what CRT adaptations can look like (Johnson, Mawyer, Thompson & Leuhmann, in press; Kang, 2019, Zeichner, 2012). Culturally responsive science teaching practices are crucial for AMNH MAT-R residents to learn given their clinical placements in diverse high-need schools in NYC and Yonkers and their commitments to teach in high-need schools following graduation. This proposed project will generate improved understanding about these teaching practices and their impact in diverse high-need settings.

There are a number of terms that capture a focus on teaching practices that account for the cultural assets of students (Ladson-Billings, 1995; Gay & Banks, 2010; Paris, 2012). The MAT-R program uses the term **culturally responsive teaching** (Gay & Banks, 2010; Hammond, 2015), which Gay (2010) refers to as the practice of "using the cultural knowledge, prior experiences, frames of reference and performance styles of ethnically diverse students to make

learning encounters more relevant to and effective for them" (p. 31). This term is also consistent with language used in the NYCDOE (NYSED, 2019). The term **culturally responsive science teaching *practices*** is used to refer to specific strategies and concrete moves teachers can make in their classroom to implement CRT. The MAT-R program focuses on helping residents with the four key aspects of CRT identified by the NYSED: c*reating a welcoming and affirming environment; fostering high expectations and rigorous instruction; identifying inclusive curriculum and assessment; and engaging in ongoing professional learning and support* (p. 25).

Grounded in these theoretical and research underpinnings, the AMNH MAT-R program: **Brings to bear AMNH's powerful combination of co-teaching between scientists and educators and its resources**—world-renowned collections, research laboratories, and exhibitions—in a new, more formal way on the challenge of improving science teaching through a novel approach to teacher preparation and STEM education in NYS and the nation. **Emphasizes Earth science, a NYS shortage area** of certified teachers (USDOE, 2017). **Targets an age range**, in grades 7–12, when an interest in science tends to drop, even when students' grades remain high (Hill, Corbetter, & St. Rose, 2011) and is a particularly critical time to maintain student interest, motivation, and engagement (Maulucci, Brown, Grey, & Sullivan, 2014; Tan & Barton, 2007). **Focuses on the teaching and learning of a set of research-based science teaching practices with explicit focus on CT and use of computer science models in the context of Earth and Space science**, critical for new teachers to master and central to effective student learning of key scientific concepts that are both rigorous and equitable. **Targets and develops understanding of the foundational ideas and dispositions of CRT** so that residents can bring the necessary habits of mind to be successful in their diverse placement classrooms and a growth and asset-based view of their pupils, families, and communities to their

work. **Supports the development of an initial repertoire of culturally responsive science teaching practices** to ensure that residents have an initial repertoire of teaching practices they can *enact* that enable them to teach with specific strategies that reflect the dispositions required to teach with a growth mindset and asset-based view. **Supports mentor teachers as they learn** alongside pre-service and new teacher residents within a residency school, in which all teachers at different levels of expertise learn together. **Produces a corps of Earth science teachers** rigorously prepared in content, including CT and CRT to teach and positively impact diverse students in high-need schools. **Increases the number of teachers** to positively impact diverse student populations. **Aims to continue to close the gaps** in achievement and graduation rates to increase readiness of diverse student populations to pursue Earth science.

Project Design

When AMNH developed its 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, including: Measuring teacher impact through student achievement; collaborations between Schools of Arts and Sciences and Schools of Education—at AMNH this entails collaboration between the Science Divisions and Education Division to jointly offer the MAT-R program through RGGS; and emphasis on clinical practice and induction, which is built upon close collaboration and partnership between the teacher education entity and schools.

The proposed MAT-R program builds upon lessons learned and **successes to date**, including: a 100 percent average pass rate on all NYS teacher certification exams, including 100 percent pass rates on the Educating All Students (EAS) and Content Specialty tests, and the edTPA; 100 percent employment in high-need schools of graduates who seek employment;

learning from the funds of knowledge from partners in high-need residency schools; and robust induction and mentor PD programs. The logic model (Appendix G) shows how TQP funds will be used to refine, expand, and evaluate the program design and outlines the MAT-R program's inputs/resources, outputs, and outcomes/impact from AY 2019–2020 through AY 2023–2024.

Effective Teaching Residency Programs (I) General

(I)(a) Supporting a teaching residency program

Since 2012, residents have entered the MAT-R program in June and begun fulfilling their three-year teaching commitment in a high-need school in September of the next year, following 14 months of preparation. The **36-credit AMNH MAT-R program**, led by a team of education and science faculty, **includes two five-month teaching residencies** in the program's NYC and Yonkers high-need residency schools, which involve ELL and special needs rotations. Residents receive mentoring from residency school teachers and AMNH educators. The program also includes two summer residences at AMNH (described below). Graduates complete three years of teaching in high-need schools, during which they receive ongoing support, including two years of induction support at AMNH followed by two years of professional support provided by the Museum's Gottesman Center for Science Teaching and Learning. The proposed project includes:

- **Clinically-oriented Earth science content courses**, offered on-site and in a blended model, that are co-developed and co-taught by science and educator faculty;
- **Clinically-oriented pedagogical courses** on topics related to theory and practice, including the effective use of data (e.g., student assessment data, scientific data) and new technologies (e.g., smart boards, student response systems, probeware);
- **Explicitly embedded practices related to CRT** in coursework and the residency school experience and dispositions developed as part of residents' identities as new teachers;

- **Integration of CT practices** as a model for science teacher preparation in program coursework and in lesson planning for residents;
- **Utilization of technology** to provide a digitally sophisticated learning environment for residents to ensure they can be successful teachers in today's digitally-enabled classrooms. Prior to implementing appropriate technology to effectively teach, assess, and engage students in Earth science concepts as described by the Next Generation Science Standards (NGSS), which have largely been adopted in NYS, residents must be comfortable with these tools and have practice using them in scaffolded environments.
- **A six-week Summer Museum Teaching Residency** at AMNH, teaching urban students in AMNH science learning programs and public audiences in exhibition halls under the mentorship of experienced Museum educators;
- **Two five-month mentored clinical residencies** in NYC and Yonkers high-need schools, during which residents will spend four days/week at the school, working closely with school-based mentors and including rotations with ELL and special needs teachers;
- **A six-week Summer Science Museum Practicum Residency** under the supervision of AMNH science faculty;
- **Mentorships by AMNH teacher education faculty** throughout the program;
- **A required digital portfolio of practice**, which serves as the equivalent of a master's thesis and is aligned with program pedagogical standards;
- Support for meeting all **state certification requirements** including the EAS and Content Specialty exams and the edTPA; and
- Support during the **three-year teaching commitment** for new teachers' transition into and retention in teaching:

- **A two-year induction program** that includes school visits and specially-designed PD activities at AMNH, and
- **Continued access** to AMNH supports and PD opportunities, including blended and online courses and travel grants that allow graduates to share experiences and expertise and that will provide the foundation for a growing professional network of Earth science educators.

(I)(b) Placing graduates…in cohorts that facilitate professional collaboration… (II)(5) Grouping of teaching residents in cohorts…

The cohort approach is used throughout the AMNH MAT-R program, from admission through induction. The approach encourages collaboration and ensures that residents see themselves as belonging to the larger professional community. Currently, candidates are admitted into a cohort of 15 residents each year; as part of the expansion efforts of the proposed project, and to increase the impact of the work, the **MAT-R program will begin admitting cohorts of 24** in the 2021-2022 AY. Once selected, candidates are subsequently placed in smaller sub-cohorts based on their residency school placements. The cohort structure is maintained in monthly full-cohort meetings, facilitated by the program co-directors, and in residency school cohort meetings, facilitated at AMNH by the Senior Specialist associated with the residency school. Senior Specialists are AMNH faculty members who co-teach academic courses and provide clinical support through 8—10 residency school visits each semester and in monthly meetings with residents and school-based mentors. Residents also work in cohorts during the Summer Science Museum Practicum Residency lab and fieldwork experiences, and the overall cohort structure is maintained during induction. Through this project, the induction program will be refined in collaboration with Dr. Irene Lee, the CT Consultant who will work

with MAT-R program faculty to develop new components that include engaging experienced graduates as induction mentors and will train these mentors in CT alongside their inductees.

(I)(c)(1) Ensuring that teaching residents receive effective pre-service preparation…

The program's first three months are dedicated to the Summer Museum Teaching Residency, the clinical component of a key course taken in residents' first summer: *Applied Research and Methods in Informal Science Settings.* **The Summer 1 Museum Teaching Residency** ensures residents receive effective preparation for their school residency placements: **Residents serve as assistant teachers to AMNH educators** three days/week over six weeks (total of 90 hours), engaging diverse urban youth and learning how teachers and scientists account for student interests and needs in teaching and mentoring. **They co-develop learning activities** that draw on AMNH resources, which they team-teach during Planetary Boot Camp, a free one-week Earth and space science institute for NYC high school students. **They gain experience using the program's Dispositions Tool** (Appendix J.2), which they use to self-assess and reflect on the important connections between the dispositions for teaching and learning (i.e., respect for difference, humility, high expectations) and the CRT practices they are introduced to in the Summer Museum Teaching Residency (including eliciting student ideas, supporting questioning, and incorporating students' funds of knowledge into learning). In addition, **workshops support residents to develop a shared understanding of the program's Observation Rubric criteria** (Appendix J.2) for effective science teaching; faculty and peers use the rubric to assess residents' teaching during a summer institute for high schools students, before it is then used by school- and Museum-based mentors to assess and support residents' pedagogical development in their school-based residencies (described below).

(I)(c)(4) The preparation…

The AMNH MAT-R program is designed for optimal effectiveness in preparing and retaining highly-effective Earth science teachers for service in high-need schools with diverse student populations, including ELL and students with special needs, with a significant focus on the use of data and technology, CRT, and CT. The 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-need public schools, the model includes two AMNH-based clinical 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 residents and strengthen retention, the AMNH program includes significant mentoring, followed by a two-year New Teacher Induction Program.

Table 1: 14-month AMNH MAT-R Program Design

<table>
<tr><th>Summer one
(10 weeks)</th><th>Academic Year
(10 months)</th><th>Summer Two
(8 weeks)</th><th>Induction Years
(2 years post-graduation)</th></tr>
<tr><td colspan="3">Courses (online and on-site)
Pedagogy (16 credits) co-taught by educators embedded CRT
Science (15 credits) co-taught by scientists and educators</td><td>Planning Forums and PD Institutes</td></tr>
<tr><td>Museum Teaching Residency
Co-teaching in youth programs (2 credits)</td><td>School Residency
Rotations with MS and HS teachers of science, ELLs and students with special needs</td><td>Museum Science Practicum Residency
Field- and lab-based experience (3 credits)</td><td>School-based supports and coaching</td></tr>
<tr><td colspan="3">Mentoring Museum team meetings (2 days/month)
Online support (ongoing throughout program)
Integrated training in CT</td><td>Mentoring
Cohort-based museum meetings (monthly), integrated support for CRT and training in CT</td></tr>
</table>

The design meets the substantial complexity and challenges of effective preparation of teachers for high-need secondary classrooms with the following components:

- **Summer 1 Museum Teaching Residency** (described above);

- **Pedagogy courses** co-developed and co-taught by education faculty that link theory with practice and applications in residency school assignments; introduce and develop dispositions for teaching diverse populations and culturally responsive science teaching practices;
- **Science content courses** co-developed and co-taught by AMNH science and education faculty, including active science learning experiences designed for application in residency classrooms;
- **Academic year-long mentored residencies** in high-need residency schools, including rotations with teachers of ELL and students with special needs;
- **Summer 2 Museum Science Practicum 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.

(II)(a)(2) Engagement…in rigorous graduate-level coursework leading to a master's degree…, and all eligible partnerships (III)(4)(b.)(f)(5)(ii) Student academic achievement standards and academic content standards…

Academic Coursework: The academic program **comprises 18 credits of Earth and space science coursework and 18 credits of pedagogical coursework spread across 12 three-credit offerings**. Faculty include active research scientists (curatorial faculty and postdoctoral researchers in the Earth and space sciences) and doctoral level education faculty, with a range of specialties including teacher education, educational technology, curriculum design, and science

education. All courses are co-taught by teams of research scientists and doctoral level teacher educators, who also bring experience teaching secondary science in urban classrooms. Faculty also includes part-time instructors, such as literacy professors, adolescent psychologists, and education historians. Guided by research on teacher learning (e.g., Darling-Hammond et al., 2005) and science teachers' learning (National Academies of Science, Engineering and Medicine, 2015) and building on AMNH's highly successful teacher professional programs that integrate scientists in the teaching of educators, the science content courses focus on the intersection between current fields of relevance to Earth science disciplines and the requirements of the NYS Earth Science Teacher Certification Exam and the NYS standards for middle and high school pertaining to Earth science. The curriculum framework prioritizes learning experiences that model instruction that supports active learning and applications for differentiated learning in the residency schools.

Key to the implementation of the residency model is the close collaboration between course faculty and school-based mentors to support a set of clinical assignments that integrate academic learning with practice-based learning in the residency schools. These clinical assignments allow faculty and school-based mentors to work with residents to support their planning for, enactment of, and reflection on culturally responsive science teaching practices. This includes a focus on rigorous and equitable science teaching practices, such as those elaborated by Windschitl et al. (2018) termed "Ambitious Science Teaching": planning for engagement with big science ideas, eliciting students' ideas, supporting ongoing changes in student thinking, and drawing together evidence-based explanations, which residents rehearse in their clinical assignments during SCI652, EDU/SCI660, EDU620, and SCI670. Windschitl and his colleagues argue that these practices have been found to increase **all students'** participation

in the classroom and in turn, represent concrete practices teachers can enact to foster an equitable classroom. All courses 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, guided by course content (see Appendix J.3 for **course titles and descriptions**) and the program's Observation Rubric and Dispositions Tool (Appendix J.2).

(II)(a)(1) The integration of pedagogy, classroom practice, and teacher mentoring….

Two 5-Month School Residency Placements and the Role of Mentors: Mentoring is critical to the residency design; numerous studies associate mentoring with a pre-service teacher's increased satisfaction with classroom success (Huling-Austin, 1992) and reduced attrition (Boreen et al., 2009; Evertson & Smithey, 2000; Smith & Ingersoll, 2004). In developing plans for effective mentoring, the AMNH MAT-R program has drawn from this literature, from the experience of residency programs with extensive mentoring components (such as the Urban Teacher Residency programs and the New Visions for Public Schools-Hunter College Urban Teacher Residency Program), and from the experience of non-residency programs offered by Teach for America and the NYC Teaching Fellows (Berry et al., 2008; Wilson, 2001).

MAT-R residents will participate in two 5-month school-based residencies, in a middle and a high school, to provide critical teaching experience in both settings with the support of school-based mentors. To further support residents' abilities to respond to the strengths and needs of diverse learners, residents complete rotations with an ELL and a special education mentor. School-based mentors are highly qualified teachers, selected by the school principals in collaboration with AMNH MAT-R faculty. Residents will spend four days each week in each of their two placements (from September - January and February - June) and will participate in parent-teacher conferences, actively sharing data about student outcomes with families—another

important practice that involves building upon resources from families, collaborating with parents, and being explicit about assessment of student learning (NYSED, 2019). Residents will also be guided by Museum-based mentors, who are AMNH Senior Specialists (described above) who observe and debrief with residents twice per month at their residency schools; meet with residents and school-based mentors at the schools once per month; and meet with residents once per month at AMNH. They offer collaborative guiding support in implementing effective teaching practices, improving school science learning opportunities, and sharing resources.

Museum Science Practicum and Induction Orientation: Following the residents' two 5-month school residencies, they will participate in a six-week, three-credit Museum Science Practicum Residency (Appendix J.3). Residents also participate in a variety of experiences designed to help them plan for the start of their teaching positions and orient them to the programming they will experience during their two-year induction period.

(II) Required Components of Teaching Residency Programs

(II)(a) Establishment and design…is based upon models…

The AMNH MAT-R program proposes to continue leveraging the strength of its established design, which is informed by research and practice in the field and enriched by the program's accumulated experience and lessons learned. Specifically, the program's use of the residency model, coupled with additional high-quality practice and experiential learning opportunities, constitute **a design that has proven successful in recruiting, preparing, and retaining strong science teachers.**

The Crucial Role of Residencies in Diverse Candidate Recruitment: The program draws from research that points to the important role residencies play in the appeal of teacher education programs to diverse applicants (Berry et al., 2008; Guha et al., 2016; Hammerness,

Williamson & Kosnick, 2016; Taylor & Klein, 2015). The monetary support often offered by residencies, coupled with intensive experience teaching in schools, is critical: research finds that students of color report that needing to take out loans often limits their choice of graduate degree programs (Carver-Thomas, 2018). This research also suggests that specific outreach to college clubs and organizations with large populations of Black and Latinx membership, including military veteran groups, scholarship groups, and historically Black colleges and universities (HBCUs), is an important strategy, along with building relationships with brokers who can help connect programs to communities of color (Simon & Johnson, 2015). The program's focus on these efforts is described below (see sections 6; 6i; 6ii on admissions, including recruitment).

Ambitious Science Teaching Practice and NGSS: The program's curriculum and coursework are informed by research that reveals the particular challenges of preparing teachers to teach science. For instance, the coursework reflects and supports an ambitious vision of learning science that is captured in standards like NGSS (NRC, 2012, NGSS Lead States, 2013) and new K-12 science curriculum (Roseman, Fortus, & Krajcik, 2015; Regents of the University of California, 2017). This model requires a fundamental shift in how teachers learn to teach science and how teacher educators prepare teachers (Windschitl & Stroupe, 2017); specifically, it requires a greater focus on key strategies, such anchoring students' learning experiences in phenomena; learning to treat students' ideas, experiences, questions, and cultural funds of knowledge as resources that help a class develop and test scientific ideas; and using a repertoire of science practices (Janssen, Woestbroek & Doyle, 2014; Windschitl, Thompson & Braaten, 2018). Initial evidence suggests that teachers with experience enacting these kinds of practices in their classrooms have a greater impact on their pupils' learning outcomes (Boyd et al., 2009). Finally, AMNH research finds that museums with exhibitions designed to engage public

audiences in exploring natural science phenomena (such as AMNH) are well-suited for preparing teachers to anchor science learning experiences in phenomena (Fallona et al., 2017; Trowbridge et al., in preparation; Howes & Wallace, in preparation, Wallace et al., in preparation).

Computational Thinking: CT refers to the thought processes involved in expressing solutions as computational steps or algorithms that can be carried out by a computer (Cuny, Snyder & Wing, 2010; Aho, 2011; Lee, 2016). Cuny, Snyder & Wing (2010) describe **analysis** as a "central activity for computational thinkers" that addresses the extent to which the abstraction (model and subsequent simulation) captures the relevant properties of the phenomenon. They state: "Computational thinkers must do certain types of analysis, including testing and experimentation, to ensure that their abstractions achieve the goals of efficient and correct behavior." As such, CT has a necessary place in modern science education; the ability to use CT and assess abstractions in computer models in a science context is part of the work of professional scientists and, as such, prepares students for future endeavors in computer science (CS) and science. Integration of CS and CT in science classes has been promoted as a strategy to engage all students in CS education. This approach aims to level inequities in access to computing education by placing CS within compulsory science classes; however, it has had limited uptake due to the difficulty of making space for teaching CS within science classrooms (Waterman et al., 2018). The AMNH MAT-R program addresses this potential and concern in the section dedicated to the Competitive Preference Priority below.

Culturally Responsive Teaching: Supporting the development of CRT practices and dispositions became a main focus of the MAT-R program when AMNH and its partner schools recognized that it was essential for preparing new teachers to be effective in their hiring schools and agreed that the work needed to be collaborative. This effort entails implementing explicit

and intentional approaches to help residents recognize and articulate inappropriate teaching dispositions (such as low expectations for students in high-need schools), develop positive teaching dispositions and actions, and develop CRT practices rooted in these dispositions. As a result, AMNH MAT-R faculty and residency school-based mentors developed a new Dispositions Tool (Appendix J.2) that provides a structure for discussion between pre-service teachers and their peers, mentors, and faculty around **important teaching dispositions, such as belief in potential for growth and respect for difference**. This tool is introduced at the beginning of the program to signal the critical nature of these dispositions throughout residents' preparation and to illuminate the central role these dispositions and practices play in MAT-R's vision of good teaching. The program continues to revise its Observation Rubric (Appendix J.2), which provides models of teaching practices that explicitly identify strategies regarding respect for students' experiences, cultures, and ideas and how to use those assets in the work of curriculum and instruction.

CRT is also a major focus for the MAT-R graduates in their second year of induction when they develop criteria for constructing and maintaining culturally responsive classroom communities (Hammerness & Kennedy, 2018). The residents work together, with support from the AMNH MAT-R program, to collaboratively develop and analyze Earth science lessons that represent CRT. Their efforts are providing locally-situated, culturally responsive lessons that the program's pre-service and first and second year teachers (and more experienced graduates) can adapt for their own teaching contexts.

(I)(c)(2) Teacher mentoring… (II)(a)(3); II(a)(3)(i); and All Eligible Partnerships (f)(8).

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

1) **Senior Specialists** in science and teacher education; and
2) Residency school-based **teacher mentors**, who are collaboratively selected by AMNH and partner school leaders and extensively prepared.

Each **Senior Specialist** co-teaches two required courses and provides mentorship to 7—8 residents in cohort groups and individually. Senior Specialists support school-based mentors and residents during twice-monthly visits to residency school classrooms to observe residents use the Observation Rubric (Appendix J.2), debrief, and identify areas for continued focus. They also identify opportunities to improve science learning opportunities and share resources.

The **teacher mentors** provide residents with daily mentoring and orientation, modeling, and feedback on school norms and the application of academic content. They use 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 Senior Specialists to become familiar with the Observation Rubric (Appendix J.2) and attend monthly meetings to develop strategies for residents to 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.

AMNH supports school-based mentors through a preparation and support program called **Mentor Academy**, designed in collaboration with the New Teacher Center (NTC) and several AMNH MAT-R program faculty who have completed NTC professional learning programs. Working closely with the residency schools, AMNH will offer the six-day Mentor Academy to prepare mentors to support residents' development of culturally responsive science teaching practices and the integration of CT practices into lessons and curriculum. Mentor Academy also

includes coaching for the co-teaching model and observational strategies to help mentors use instructional data to improve residents' teaching practice and deep exposure to and experience with clinical assignments that target development of high-leverage science teaching practices. *(7)(a) Support for residents…through an induction program...(I)(c)(3) Support required through the induction program…; and each eligible partnership (g)(1)(2)(3)(4).*

The New Teacher Induction Program is based on practice and research derived in part from the work of the NTC and AMNH's years of experience in teacher PD. The induction reflects findings that classroom assistance, observation, feedback, and coaching from experienced faculty are particularly important to the **retention of teachers in the early years of teaching** (California Commission on Teacher Credentialing, 2015; Headden, 2014; Ingersoll & Strong, 2011). Research suggests that induction support may be especially important for teachers of color, who are more likely to move schools or leave the profession than are white teachers (19 percent versus 15 percent) (Carver et al., 2018).

As a critical component of the program's efforts to retain teachers, the New Teacher Induction Program provides all graduates with two years of intensive, sustained support following graduation (Wong, 2004, Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). Complemented by remote participation strategies, the induction program includes four main components: 1) school-based classroom coaching, 2) monthly support sessions at AMNH, 3) summer induction activities, and 4) planning forums scheduled throughout the year. The induction program also provides classroom resources (e.g., globes, topographic maps, a technology lending library) to participants. The program values teachers' professional time, and all participants receive a $25/hour stipend for monthly support and PD sessions.

The induction program's goal is to support the accelerated development of new teachers'

understanding and implementation of effective science teaching in high-need schools, with the expectation that graduates will become leaders in their hiring schools. The program has three objectives: 1) develop graduates' abilities to enact the high-leverage teaching practice of surfacing and working with students' thinking and experiences in science, including CT, 2) expand graduates' abilities to address the needs of culturally and linguistically diverse students in science, and 3) strengthen graduates' abilities to foster students' engagement in and understanding of science through the use of informal science resources. The induction program also helps graduates develop their leadership skills by providing a supportive and challenging professional learning community.

As graduates finish their induction and begin their third year of teaching, they join a growing cadre of AMNH MAT-R graduates in supporting each other. The Induction Planning Forums are one example of support provided to the program's more experienced graduates to further develop and become leaders. The program recruits third-year teachers to lead Planning Forums for first- and second-year teachers in the induction program with the support of program faculty. These teachers develop their teacher leader capabilities and receive small honoraria for their time. Graduates are supported through annual check-ins by a Senior Specialist and continue to have free access to the full range of AMNH on-site and online PD opportunities for as long as they remain in teaching. Finally, as important aspect of their growth in the profession, each graduate in their third year of teaching has support to attend the National Science Teachers Association (NSTA) national conference on science education. The program monitors employment of all graduates during the three-year teaching commitment to ensure compliance.

(4) …clear criteria for the selection of mentor teachers… (4) (iii) Collaboration with colleagues to improve instruction…(4) (iv) Analysis of gains in student learning…

Mentor selection criteria include: 1) certification in the subject they teach; 2) at least three years of teaching experience; 3) deemed an exemplary teacher by their principal; 4) participation in PD and mentoring activities; 5) highly rated by AMNH faculty during classroom observation; 6) interest in mentoring and commitment to program requirements, such as progressive release of teaching responsibilities; and 7) evidence of ability to analyze data to reflect upon and plan for instruction resulting in improvements in student learning.

(4)(i) Planning and preparation… (4)(ii) Appropriate instruction…

Mentor teacher effectiveness is collaboratively evaluated by AMNH senior leadership and residency school administrative leadership. The process includes confirming a principal's recommendation through AMNH observation of teaching. The criteria include evidence of effective planning, pedagogical content knowledge, communication and questioning skills, respect for students, and the use of student-centered strategies.

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

The AMNH MAT-R program envisions an enlarged role for mentors, expanding their responsibilities beyond mentoring residents during school residency placements by enlisting their continued guidance and support 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 still growing their own practice. To meet this challenge, AMNH MAT-R proposes to conduct an **assessment of mentor needs, including with respect to CRT and CT,** during project Year 1. In project Year 2, the program will set goals and develop PD opportunities for mentors appropriate to their needs (including access to AMNH'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 mentors as described above to identify potential teacher leaders in residency schools and/or as PD providers at AMNH. Mentors thus are not only mentoring residents through graduation and into their career launch, but also strengthening their own science teaching practices.

(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 (Appendix J.5), including: 1) stipends of $500/semester; 2) stipends of $200/day for participation in the six-day Mentor Academy; 3) stipends of $500/AY for mentors who participate in induction activities; 4) one-year memberships to NSTA and TESOL; 5) AMNH family membership for one year; 6) free registration in AMNH PD programs; and 7) classroom assistance, including field trip planning guidance and vouchers for paid exhibitions to supplement free general admission for NYC schools.

(6) The development of admissions goals and priorities…(6)(i); (6)(ii)

Recruitment: The program faces two recruitment challenges: 1) the small number of individuals with the Earth science undergraduate degree (or equivalent course work) required by NYS for MAT programs preparing secondary science teachers for Earth science, and 2) the lack of diversity in this limited pool. In 2013-2014, the National Center for Education Statistics reports that of the 1,870,000 bachelor's degrees conferred across all fields, 5,800 were in the physical sciences and science technologies (of which Earth science is just one of several disciplines). To address this limitation, the program conducts vigorous outreach and has been successful in its overall recruitment efforts to date. Recruiting a diverse student body from a small pool entails even greater challenges. The MAT-R program has, however, overcome these challenges, and graduates from the past 6 cohorts (2013-2014 through 2017-2018) have ranged from 11 to 65 percent members of underrepresented groups, with an average of 28 percent, or

more than 3-5 times as many as in the pool of graduates with physical and Earth science degrees. Additionally, 59 percent of matriculating students in the first 6 years (2013-2019) self-identify as women. For this project, the MAT-R program proposes to use the strategies discussed below to expand its recruitment of a diverse applicant pool, in race and ethnicity, and in life experiences.

Working More Closely with Minority-centered Professional Organizations: The project will focus closely and determine a better method for tracking outcomes in its outreach to professional and service organizations. It is a program priority to maintain and improve upon success to date in recruiting minority applicants, and the program will focus on outreach to organizations that work with minority students and professionals in the Earth sciences.

Working with Veterans' Organizations: This project will build more robust relationships with veterans' organizations and programs for veterans, regional colleges, and universities, with a goal of increasing veterans' admissions to at least one per cohort.

Increase Direct Outreach: The program has contracted with Educational Testing Service (ETS), the owner of the Graduate Record Examinations (GRE) exam, to reach out by email and postcards to GRE test takers who indicated an Earth science-related major. The MAT-R program will continue to monitor this approach's effectiveness; anecdotally, applicants who have called for information and attended Open Houses report that they heard about the program through a GRE mailing.

(7)(b) Selection of individuals as teaching residents. (7)(b)(1); (7)(b)(1)(i); (7)(b)(1)(ii)

Applications will be accepted from August 31st—January 31st each year and assessed for basic eligibility, including a minimum GPA of 3.0 and a minimum of 30 credits in Earth and space science (or 24 credits with 6 credits in related science fields). Eligible applications will be reviewed by a team of AMNH MAT-R education and science faculty, using specific rubrics to

assess applicants' strengths in scientific preparation and potential to teach. 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, which must be fulfilled before graduation); and
- Completion of an online application that includes college transcripts, several short answer questions, and an essay on a pertinent educational topic, which demonstrates writing skills.

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

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. An applicant's suitability and potential are also evaluated through three personal references.

II(b)(2)(ii) Strong verbal and written communication skills, and II(b)(2)(iii) Other attributes linked to effective teaching.

Based on the application reviews, candidates will be selected for interviews conducted by an AMNH science educator, a RGGS scientist, and a school-based mentor or principal, either face-to-face or via Skype to probe: 1) additional information identified during the application review; 2) attitude towards teaching; 3) interest in educational topics via discussion of a recent education article; 4) interest in and attitude towards high-need schools; and 5) writing and communication skills via a writing sample. The interview teams will bring their

recommendations to the admissions committee comprised of three science faculty, three education faculty, and one program co-director for discussion and vote.

(7)(c) Stipends or salaries; applications; agreements: repayments. (7)(c)(1); (7)(c)(2); (7)(c)(3); (7)(c)(3)(i); (7)(c)(3)(ii); (7)(c)(3)(iii); (7)(c)(3)(iv); (7)(c)(3)(v)

Upon selection, candidates receive a letter of admission and a program support letter that details the amount and conditions of the stipend, the full tuition fellowship, other program benefits, including books and technology resources, and details of the service obligation upon graduation (Appendix J.6).

(7)(d) Repayments. (7)(d)(1) In general; (7)(d)(2); (7)(d)(3)

Upon acceptance of an offer of admission, each admitted candidate must sign a program agreement including the conditions of support, the of teaching service for at least three years at a high-need school 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 (Appendix J.6).

Competitive Preference Priority 1: Prepare Educators to Deliver Rigorous Instruction in Computer Science and Improve Student Achievement.

…improve student achievement or other educational outcomes in computer science

The definition of computer science related to the Competitive Preference Priority 1 includes the following language: "… ***the expanding field of computer science emphasizes computational thinking and interdisciplinary problem-solving to equip students with the skills and abilities necessary to apply computation in our digital world*.**" Addressing this potential, the proposed project supports the integration of CT through the co-development of computer modeling and simulation activities that reduce the demands of teaching computer science while

retaining the power of CT in science contexts. Specifically, the project's innovation is its focus on three aspects of CT: using computer models as experimental test beds; engaging in data collection and analysis; and investigating the abstractions made in computer models of scientific phenomenon. The MAT-R curriculum will be innovated to serve the dual goals of exposing learners to computer science as a powerful tool for understanding systems in the science context while simultaneously promoting learner's understanding of modern scientific practices.

In doing so, the MAT-R program answers the NGSS' call for a shift in K-12 science education from a focus on knowing scientific facts to **reasoning about phenomena** through modeling (NRC, 2012). The MAT-R curriculum will position CT within science classrooms through the use of computer models of scientific phenomena and argumentation of the validity of the models based on understandings of the phenomenon modeled and analysis of data generated by the models. In addition, the MAT-R program's integration of CT aligns with the Equity and Excellence Agenda for NYC from Mayor Bill De Blasio to "ensure all students receive a world-class education and have the opportunity to reach their full potential." Specifically, Computer Science for All (CS4All) is one Equity and Excellence initiative: "Through CS4All, NYC students will learn to think with the computer, instead of using the computers to simply convey their thinking. Students will learn ***computational thinking***, problem-solving, creativity, and critical thinking. They will also learn to collaborate and build relationships with peers, communicate and create with technologies, and to better understand technologies we interact with daily" (NYCDOE, 2019).

The proposed project will enable the AMNH MAT-R science faculty to make connections between CT and scientific explanations for natural phenomena studied in the curriculum they already use. The project proposes to innovate the way that the residents think

about and teach the phenomena that are studied in the Weather and Climate and Space Systems courses using appropriate and currently available models and tools (Carbon Connections Climate Model (BSCS, 2019): http://carbonconnections.bscs.org/curriculum/unit-03/ecm-full/; edGCM (Educational Global Climate Model, NASA Goddard GISS): http://edgcm.columbia.edu; and OpenSpace (AMNH, 2019); https://www.openspaceproject.com). These innovations will include revised assignments that residents will implement using these tools in their residency schools and are reflected in their students' work. Using computer software to visualize space science data and model climate change, residents and their secondary students will investigate these abstractions of scientific phenomenon to understand and articulate CT concepts and processes.

Specific content from the NYS P-12 Science Learning Standards related to phenomena that scientists study in astrophysics and climate science using computer models are listed in Appendix J.4. Teaching and learning aligned with the new standards requires understanding the disciplinary core content ideas in the context of the Science and Engineering Practices and Crosscutting Concepts. The program will focus on Practice 2, Developing and Using Models and Practice 5, Using Mathematics and Computational Thinking. The CT curricular innovations will attend to these standards and to the CS4All (Computer Science for All) Blueprint for NYC Schools, which has developed a framework for understanding computer science and CT concepts and practices.

During Year 1, the planning year of the project, MAT-R faculty will work with CT expert Dr. Irene Lee to identify opportunities for integrating new components in the program's current courses that focus on grade level appropriate CT skills. As part of this work, Dr. Lee will plan and deliver webinars on CT that will serve as educative materials for faculty and provide CT learning resources that the MAT-R program can leverage for graduates and partner school

leaders and mentors. In Year 2, the pilot year, Dr. Lee will advise on refining components and materials based on feedback from faculty who taught the new course(s) and MAT-R residents' and classroom mentors' experiences during the courses, including their learning outcomes and teaching experiences. Dr. Lee will also work with MAT-R faculty to adapt the CT webinars for use with program graduates during induction and for more experienced teachers. Throughout Year 3, the first implementation year within MAT-R partner schools, Dr. Lee will advise on additional refinements/revisions to the MAT-R courses and on issues related to the integration of CT in day-to-day secondary science classrooms. The CT components will then be implemented and refined by MAT-R faculty in Years 4 and 5. In addition, Dr. Lee will assist MAT-R faculty with identifying appropriate online course(s) that the program will recommend to MAT-R graduates interested in offering computer science electives in their schools. Support will be provided to cover the costs of these courses.

III. Eligibility Information

(III)(4)(b.) General Application Requirements: Eligible Partnership…

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.

(III)(4)(b.)(a) A needs assessment of the partners…

The MAT-R program identified four large urban districts (Bronx, Queens, Brooklyn and Yonkers) as LEAs with a high density of high-need schools (>50% economically disadvantaged students) (Appendix C).

(III)(4(b.)(c) …prepare prospective and new teachers to understand and use research and data to modify and improve classroom instruction.

One of the MAT-R program's goals is for residents to be able to analyze patterns of student learning for an entire class, observe the similarities and differences among the group and individuals, assess their impact on learning, and reflect on this information to inform their future instructional choices. For example, in EDU640 *Methods and Assessments in Student Science Research*, taught during the spring school residency, residents guide, support, and analyze students' abilities to construct a scientific explanation for a phenomenon related to the topic being taught, analyze their teaching effectiveness using a pre-post measure, and describe changes they will make to their instruction based on observed students' learning. In addition, the program introduces the Analyzing Student Work (ASW) tool in Mentor Academy (described above), and mentors and residents are encouraged to use this tool collaboratively to support student learning in their residency classroom. The ASW tool is also used routinely with first- and second-year graduates as part of the New Teacher Induction Program to support a focus on student work among new teachers. Residents are also monitored and given feedback through the program's Observation Rubric (Appendix J.2) throughout each semester-long residency on their ability to "use a variety of assessment strategies to assess students." The proficient performance level states "Uses a variety of assessment strategies (both informal and formal) that allow for all student to effectively demonstrate achievement of learning goals." From the lens of CRT, learning to use alternative metrics for assessing learning also fosters an appreciation for different learning styles and promotes multiple assessments of academic growth (NYSED, 2019, p.27).

(III)(4)(b.)(e) An assessment that describes the resources available…

Partner district superintendent commitments: The four partner school district superintendents represent NYC and Yonkers, both high-need districts, and commit to:

- Identifying one to two secondary schools to serve a majority of economically disadvantaged students to partner with AMNH as clinical residency schools, each with a minimum of four well-qualified science teachers, as well as an ELL teacher and a Special Education teacher, each with STEM teaching experience, to serve as mentors;
- Collaborating with AMNH MAT-R staff to plan for the program implementation during the 2019-2020 AY, participate in mentor preparation, and pilot new components during the 2020-2021 AY, and provide clinical placements and supervision for up to four residents in the fall and up to four residents in the spring of each AY: 2021-2022, 2022-2023, 2023-2024.
- Identifying opportunities to hire program graduates in high-need schools in their district.

A sample school partnership MOU appears in Appendix J.5.

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 RGGS.

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

CT Consultant commitments: Dr. Irene Lee brings considerable expertise to her role as the CT Consultant. She has committed to advising the MAT-R faculty on integrating new components into the current science courses that focus on grade-level appropriate CT skills and to providing webinars on CT that will serve as educative materials for program participants. In Year 2, the pilot year, Dr. Lee will advise on the refinement of components and materials based on feedback from educators/mentor teachers who taught the new course(s), and MAT-R

residents' experiences during the course, including their learning outcomes and teaching experiences. Throughout Year 3, the first implementation year within NYC schools, Dr. Lee will advise on additional refinements to the MAT-R courses and on issues related to the integration of CT in science classrooms. She will regularly collaborate with MAT-R faculty to identify opportunities within the science coursework that the residents complete for the integration of CT.

(III)(4)(b.)(e) (1) The integration of funds from other sources…

AMNH has a broad base of support and a long history of successful fundraising for education initiatives. In addition to funds from private sources and from the institution, other sources of funding anticipated to supplement the TQP funding include residency support and stipends for residents in 2019-2020 and 2020-2021 from NSF's Robert Noyce funding.

Numerous other AMNH resources are integrated into the MAT-R program, including: 1) experience administering graduate programs through RGGS; 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) experience working with schools to improve science teaching and learning; 4) experience offering mentored research opportunities; 5) a robust slate of on-site and online teacher PD programs that serve some 3,000 teachers annually; and 6) exhibitions, exhibition-related resources, classrooms, and laboratories that scaffold teacher and student use of AMNH.

(III)(4)(b.)(e) (2) The intended use of the grant funds…

The intended use of grant funds is presented below in Table 2 to illustrate how the activities of the program are to be carried out, when, and by whom.

Table 2: Use of TQP Funding Academic Years 2019 through 2024

2019–2020	2020–2021	2021–2022	2022–2023	2023–2024	Personnel
Manage	Manage	Manage	Manage	Manage	Kinzler

TQP planning, revisions, and research	TQP planning, revisions, and research	TQP planning, revisions, and research	TQP planning, revisions, and research	TQP planning, revisions, and research	Curtis-Bey
Review residency school partnerships and plan for revision, PD, and mentoring for partner and employer schools	Revise residency school partnerships, PD, and mentoring for partner and employer schools, establish agreements to add new schools	Implement and ongoing monitoring of residency school partnerships, PD, and mentoring for partner and employer schools	Implement and ongoing monitoring of residency school partnerships, PD, and mentoring for partner and employer schools	Implement and ongoing monitoring of residency school partnerships, PD, and mentoring for partner and employer schools	Kinzler Curtis-Bey Super-intendents
Develop research project design; coordinate formative, summative and impact evaluation	Baseline research; coordinate formative, summative and impact evaluation	Implement research; coordinate formative, summative and impact evaluation	Implement research; coordinate formative, summative and impact evaluation	Analyze and disseminate preliminary research findings (*research continues post-grant)*; coordinate formative, summative and impact evaluation	Hammer-ness Kinzler Curtis-Bey
Plan program innovations for CT and refine ongoing CRT components	Field test innovated and refined structures and methods	Implement innovated and refined structures and methods in MAT-R program for C10	Implement innovated and refined structures and methods in MAT-R program for C11	Implement innovated and refined structures and methods in MAT-R program for C12	Curtis-Bey Kinzler
	Recruit, select, admit TQP C10	Recruit, select, admit TQP C11	Recruit, select, admit TQP C12		Kinzler Curtis-Bey
		Graduate TQP C10	Graduate TQP C11	Graduate TQP C12	Kinzler Curtis-Bey
Mentor assessment	Induction TQP C7 (prepared with funds from the 2014 AMNH TQP project)		Induction TQP C10; mentor PD	Induction C11 (*induction continues post-grant);* mentor PD	Curtis-Bey

(III)(4)(b.)(e)(3) The commitment of the resources of the partnership….

The AMNH MAT-R program is an institutional priority. The AMNH 2012 Strategic Plan emphasizes the Museum's vital role as an institution with unique resources, expertise, and capabilities to help address the nation's crisis in STEM education. AMNH is committed to sustaining the MAT-R program through a combination of private philanthropy and federal and state support as long as the need for Earth science teachers persists. The MAT-R program draws on AMNH's strengths and committed resources:

Active scientific research enterprise: AMNH's robust scientific research enterprise encompasses a scientific staff of over 200, including over 40 members of the curatorial faculty (equivalent to tenured or tenure-track university faculty). Faculty are engaged in scientific research and professional training of scientists in the physical and life sciences, paleontology, and anthropology. AMNH research includes over 120 annual field expeditions and is supported by cutting-edge laboratories. Its collections include 34 million specimens and artifacts.

Expertise in graduate education in science: AMNH has a long history in the graduate education of scientists. Most AMNH faculty have academic appointments at partner institutions, which include CUNY, Columbia University, Cornell University, and NYU.

Expertise in graduate teacher education and PD: AMNH offers a range of on-site and online programs that support science teaching and learning among teachers and within the K–12 education system. AMNH-specific instruction focuses on developing content knowledge and inquiry-based approaches to teaching in classrooms and other settings. AMNH offers graduate-level courses to almost 150 teacher candidates annually (including Teach for America candidates, NYC Teaching Fellows, Teacher Opportunity Program candidates, and candidates following traditional routes) who are enrolled in teacher education programs offered by partners such as Bank Street College of Education, Teachers College of Columbia University, Barnard

College, and multiple CUNY campuses. It also offers on-site and online teacher PD programs that serve some 4,000 teachers annually. Examples include:

- **Teacher Renewal for Urban Science Teachers (TRUST) Summer Institute** is a 60-hour, three-credit program co-taught by teams of AMNH scientists and educators offered in partnership with CUNY to prepare new, certified science teachers for NYC schools. To date, 14 institutes have been offered, serving approximately 560 teachers.
- **Seminars on Science** is a program of online PD courses for pre- and in-service K-12 educators that offers graduate credit through partnerships with 9 colleges and universities. There have been approximately 15,450 enrollments since 2000 from around the world.

A track record of success partnering with schools: AMNH has pioneered a new, more active role for informal science institutions in leveraging their resources in structural partnerships with schools to improve the teaching and learning of science, family engagement, and student outcomes. As an example, please see the description above of the Urban Advantage program.

Experience offering mentored practicum opportunities: Since 1989, AMNH has offered NSF-funded Research Experiences for Undergraduates (REU) summer programs, in which undergraduate students conduct research with a scientist mentor. Almost 80 percent of participants in the first 10 years went on to graduate or professional school, and more than 30 percent of those are currently in tenure-track faculty positions. AMNH also offers a similar program for high school students, the Science Research Mentoring Program (SRMP), which has received support from NSF's ITEST program and National Aeronautics and Space Administration (NASA) and annually serves 60 under-resourced students. A NSF-funded longitudinal study is currently underway to track graduates' pathways as they move towards higher education. Early findings show that a majority is pursuing STEM careers and participation

in the program is impacting their abilities to seek out and complete research opportunities while at college and excel in their early classes.

(III)(4)(b.)(d)(2) How the activities of the partnership will be consistent with…reform activities…

Analysis of the AMNH MAT-R to date illustrates considerable success in recruiting, preparing, and retaining STEM teachers. Findings from the first three cohorts of AMNH MAT-R graduates indicate that the retention rate is consistent with the average rate reported by residency programs and is far above the national average for teachers prepared across all programs working in high-need schools and teaching in subject areas for which there are teacher shortages. In the 2017-18 AY, 82 percent of Cohort 1–3 graduates (41 of 50) were teaching. Of those, 88 percent (36 of 41) were teaching in high-need schools, and 95 percent (39 of 41) were teaching in NYS.

(f)(1) How the eligible partnership will meet the purposes of the TQP grant program…(f)(2) How the partnership will carry out the activities required under Absolute Priority….

(III)(4)(b.)(d)(1) How the eligible partnership will coordinate strategies and activities…

The goal of AMNH MAT-R program is **to develop and implement a highly effective residency program working with a robust set of partners to meet the critical shortage area of certified Earth science teachers prepared to increase student achievement in high-need schools throughout the United States**. The program has identified 4 partner schools (Roosevelt High School, Hunters Point Community Middle School, Sunset Park High School, and Highbridge Green Middle School) where over 50 percent of students are eligible for free or reduced price lunch and currently, each has the correct amount of available teachers to serve as mentors. Partnership with these schools are represented by the letters of support from their respective district superintendents, who will work with the program to confirm that the necessary

quantity of mentor teachers is still available, and identify new partnership schools if the 4 identified here can no longer provide enough mentor teachers. Additionally, per their letters (Appendix I), the superintendents will collaborate with the MAT-R program to identify two new partner schools for a total of 6 as part of the expansion of the program. The program's faculty will work closely with the principals at each of the partner schools to implement the residency, including selection of mentors, placement of residents, and collaborating with mentors in the monitoring and assessment of residents' growth. Partnerships will be assessed annually based on availability of science teacher mentors and Special Ed and ELL teacher mentors with STEM teaching experience, evidence that residents are able to develop their teaching skills and dispositions garnered through use of the MAT-R Observation Rubric and Dispositions Tool (Appendix J.2), and that the program has positive impacts on student learning. Data will be shared with partner school principals each year and used as the basis for recommendations to the superintendent about continuing the partnership. Table 3, 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.

Table 3: Alignment of AMNH Program with TQP 2019 Goals and Purposes

TQP Goals and Purposes	Absolute Priority	Competitive Preference #1
AMNH MAT-R Program Components	√	√
MAT-R recruitment admissions, and selectivity	√	
Academic Coursework in Science	√	√
Online Science Course	√	√
Space Systems	√	√
Earth Evolution and the Earth System	√	√
Weather, Climate and Climate Change	√	√
Earth Science Literacy Journal Seminar	√	√
Academic Coursework in Pedagogy	√	
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	√	√
Residencies	√	√
Museum Teaching Residency	√	√
Academic Year Residency/Mentoring	√	√
Museum Science Practicum Residency	√	√
Induction		
2 years of Induction/mentoring	√	√

(III)(4)(b.)(f)(6) ... prepare general education teachers to teach students with special needs...; (f)(7) ...to teach students who are limited English proficient; and (f)(8)(ii) ... implement literacy activities...;

The program aims to graduate individuals with a strong understanding of variations in learner development and specific learning differences and of how to create learning environments that engage **all** students in standards-based science content. MAT-R residents learn to support a range of learners, including ELL, students with special needs, students who struggle with reading or mathematics, and gifted students. Through multiple assessments, including the edTPA and EAS exams, the program regularly monitors how well it is preparing teachers who can engage all of their students. In particular, the EAS exam provides evidence for the graduates' successful development of knowledge of research-validated instructional strategies that are responsive to the characteristics and learning needs of students with a broad range of backgrounds and needs. It also provides evidence that graduates have the knowledge to act in accordance with their legal, ethical, and professional responsibilities in education-related situations involving students and parents/guardians. All MAT-R graduates pass the EAS exam with the majority doing so on their first attempt, and, overall, the mean score of 535 is above the statewide average and minimum pass score.

Science teachers, including ELL and special education teachers, at residency and

employing schools will be invited to participate in ten hours of PD offered by the Gottesman Center (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 of 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.

(III)(4)(b.)(f)(11) ***…****collect, analyze, and use data on the retention of all teachers …located in the geographic area served by the partnership to evaluate the effectiveness of the partnership's teacher and education support system.*

Employment hiring and retention rates are extremely important indicators of program success and are monitored closely by the MAT-R program co-directors and relevant oversight committees; this data is used to inform program design. Currently, 94 percent of eligible graduates have persisted in teaching beyond 3 years. The MAT-R program's high retention rate is expected from a program that requires a teaching commitment; however, as the program

continues, long-term retention of graduates in teaching will be actively monitored and supported. The program tracks and updates graduates' teaching status and place of employment annually.

Through the New Teacher Induction Program, faculty members visit graduates in their classrooms during their first two years of teaching. This affords a unique opportunity to observe graduates in action and confirm they are applying the skills learned during the MAT-R program. The focus of each school visit is determined in consultation with the graduates based on their self-identified needs, and visits are intended to be formative and coaching rather than evaluative. NYS does not share information with its teacher preparation programs regarding the performance of their recent graduates, such as teacher evaluation results or value-added measures of impact on student learning. NYS collects data on the performance of the graduates of its Educator Preparation Providers (EPPs) but data are not shared or compared. The NYSED website on the state report card for higher education reports that there are no data available for 2016-2017 or 2017-2018 (https://data.nysed.gov/lists.php?type=higher). Therefore, in 2012, the program contracted with New York University (NYU) researchers to engage in an ongoing quantitative study of MAT graduates' impact on student learning. NYU researchers are finding that MAT-R graduates are teaching in schools with higher needs than comparison beginning teachers and that the number of students taking the Earth Science Regents exam increased in schools that hired MAT-R graduates. This finding demonstrates that the MAT-R program is meeting its objective of placing well-qualified new science teachers in high-need schools and expanding opportunities for learning. Additionally, students of 2013–2014 graduates (Cohort 2) and 2014–2015 graduates (Cohort 3) are between six and 11 percentage points more likely to pass the Earth Science Regents Exam at the 65 percent level than groups of similar students. This impact evaluation will continue through the proposed project with NYU researcher, Dr. Meryle Weinstein.

Management Plan

Under TQP regulations, AMNH serves as the partner institution, through its Richard Gilder Graduate School. Rounding out the partnership are four high-need school districts in Yonkers, Queens, Brooklyn, and the Bronx (Appendix I). A **collaborative project leadership team** will manage project design and implementation, induction and continued PD, evaluation, and compliance. The project will be managed by PI **Rosamond Kinzler, Ph.D.**, Senior Director of Science Education and Director of AMNH's National Center of Science Literacy, Education, and Technology and co-PI **Linda Curtis-Bey, Ph.D.**, Senior Director of Education. The pair will meet monthly during the first and second years of the project and at regular intervals in subsequent years. Dr. Kinzler will oversee the grant, supervise the science faculty and the Museum Science Practicum Residency, manage recruitment and admissions, and co-teach one course. Dr. Curtis-Bey will supervise the education faculty and the Museum Teaching Residency and co-teach one course. Dr. Kinzler and Dr. Curtis-Bey will work collaboratively with the partner superintendents to identify six schools to serve as clinical partners, and Dr. Curtis-Bey will supervise program elements pertaining to school residencies, including the mentor program, the Induction program, and ongoing PD for graduates. Dr. Kinzler and Dr. Curtis-Bey will collaboratively work with the Computational Thinking Consultant Dr. Irene Lee to oversee the development, piloting, and implementation of the CT innovations across the program.

Directly supporting Dr. Kinzler and Dr. Curtis-Bey will be a management team of: partner residency school principals; and lead teaching faculty members **Denton Ebel**, **Ph.D.**, Curator, Department of Earth and Planetary Sciences, Professor, RGGS, and **Melanie Hopkins**, **Ph.D.**, Associate Curator, Department of Invertebrate Paleontology, Professor, RGGS (curator appointments are comparable to tenure and tenure track university faculty appointments). This

team is supported by senior staff **Robert Steiner, Ph.D**., who is responsible for the program's use of innovative technology; **Preeti Gupta**, **Ed.D**., Director of Youth Initiatives, which is the site of the Museum Teaching Residency; and **Nathalie Goodkin Emani, Ph.D.,** Assistant Curator in the AMNH Department of Earth and Planetary Sciences. The teaching faculty also includes AMNH science educators **Hudson Roditi, Ph.D.,** with extensive multilingual experience; **Christina Trowbridge, Ph.D.**, on the induction staff and lead of the Mentor Preparation Program. The clinical faculty include **Julie Contino**, **Ed.D**., an Earth science teacher educator, **Natasha Cooke-Nieves**, **Ed.D.**, a science curriculum specialist and teacher educator, both with extensive experience teaching in NYC science classrooms; and **Elaine Howes**, **Ph.D**., a teacher educator with extensive university-based teacher preparation experience who will serve as Museum-based mentors, clinical supervisors, and also co-teach courses. **Karen Hammerness, Ph.D.,** AMNH's Director of Educational Research and Evaluation, will assist in the coordination of the evaluation work with Horizon Research (in the interpretation and review of findings from the evaluation and support considerations of their implications for program design) and the impact evaluation work with **Dr. Meryle Weinstein** at NYU. She will also lead the research project. The project will be supported by a cadre of experienced AMNH administrative personnel including the MAT Assistant Director of Administration.

The program is governed by the MAAPC (MAT Academic Affairs and Program Committee), a body within RGGS at AMNH. This committee is co-chaired by Dr. Curtis-Bey and Dr. Kinzler and comprised of three scientist members of the MAT faculty and three education members of the MAT faculty. The committee also includes a partner school principal and (ex officio) a program graduate, the Dean of RGGS, and the Sr. Vice President for Education. The committee meets three times per year to address issues relating to faculty,

admissions, student support and advisement, and curriculum. The program is overseen by the CMDP (Committee for MAT Degree Programs), which is comprised of the Dean of RGGS, the Provost for AMNH, and the Sr. Vice President for Education, and meets annually to review key program metrics and guide long term planning.

The project will be guided by an external advisory board, a structure which has provided expertise to AMNH since the beginning of the program. This group meets once a year and the membership proposed is Dr. O. Roger Anderson, Dr. Bronwyn Bevan, Dr. Albert Byers, Dr. Kim Kastens, Dr. Sharon Locke, Dr. Mark Windschitl, Jasper Steenhuis (teacher, NYC), Dr. Gail Joyner White (former principal, Yonkers), Sarah Holloway (Co-founder of CS4All), and two alumnae of the program: Melissa Schumer and Sean McFadden, who teach in high-need schools in NYS. The group will meet virtually in years 1 and 2 and on-site in years 3, 4, and 5 with additional consultations as needed. **Evelyn Gordon**, Senior Researcher at Horizon Research, and **Sean Smith**, President of Horizon Research, will serve as external evaluators and attend meetings of the Advisory Board.

Project Evaluation

(f)(4) The partnership's evaluation plan…

A strong evaluation plan is in place to measure the effectiveness of the project in reaching its goals and provide formative feedback throughout the project. Horizon Research, Inc. (HRI) has over 30 years of experience evaluating K–20 STEM education initiatives and will conduct the external evaluation, which will have formative and summative components, each guided by a set of questions. The former will provide feedback to project leadership to inform mid-course adjustments. The latter will gauge the extent to which project goals are achieved, addressing the TQP Performance Measures as well as other indicators. Additionally, Dr. Meryle

Weinstein will oversee impact evaluation efforts under the supervision of Dr. Karen Hammerness, who will also lead the research component of the project.

The formative evaluation questions are aligned with the project's key activities and Table 4 describes how the evaluation will address each question. The evaluation includes a multi-method, multi-source approach to addressing the questions. For example, the first two years, when the project team will develop CT course materials and revise current CRT content, will be critical to the overall success (Formative Question 1). HRI will observe a sample of project meetings by videoconference to understand the tradeoffs the project has to negotiate, review products to offer an external perspective on quality, and interview field test faculty and residents to gauge usability and effectiveness of the materials. Similarly, HRI will use evidence from several data sources to examine the quality of the enactment of these revised course elements (Formative Question 6), including observations, course evaluations, and interviews. MAT-R's success also hinges on being able to attract, prepare, and support effective school-based mentors (Formative Question 4). To provide feedback on this, HRI will observe mentor programming and survey mentors about the quality of these experiences. HRI will also interview residents about their experience being mentored, focusing on the extent to which mentoring aligns with project goals and residents' needs. HRI will provide formative feedback on an as-needed basis both formally, through memos, and informally, through emails, phone calls, and project meetings.

The summative evaluation will focus on project outcomes and impacts, MAT-R's goals include specific targets for persistence in the program, certification, high-need school placement, and teacher retention (Summative Question 2). Again, illustrating the evaluation approach (see Table 4), HRI will collect data annually on each of these outcomes. In addition to providing final, summative results for all years of the project, HRI will report certification/licensure,

graduation, one-year persistence, one-year employment retention, and three-year employment retention interim results each year to address Performance Measures 1–5.

The project also aims to positively impact graduates' preparedness as Earth science teachers, including their preparedness to use CRT practices and implement CT activities. HRI will interview and survey new teachers annually regarding their own assessment of their preparedness. In addition, HRI will analyze ratings given by AMNH mentors. HRI will detail findings from the summative evaluation in a report to the project each year.

Table 4. Questions, Data Sources and Timeline (See Appendix J.7 for Analysis Methods)

Formative Evaluation Question	**Data Sources**	**Years**
1. What are the nature, quality, and outcomes of the course revision process with respect to developing new CT components, refining CRT content, and developing additional guidance for supporting ELL students and students with special needs?	Documents reviews, Meeting observations, Interviews with field test faculty and students	1-2
2. To what extent is the project able to attract diverse, well-qualified applicants and select and enroll them as residents?	Demographic data for applicants and residents	2-4
3. To what extent do AMNH and district superintendents function as partners to develop admissions goals and priorities, identify residency schools, and build partnerships with those schools?	Annual one-on-one interviews with leaders from AMNH and from partner districts and schools	1-5
4. To what extent is the project able to attract, prepare, and support school-based mentors?	Teacher effectiveness data and subject area knowledge for mentor teachers, Observations of a sample of mentor program activities, Survey of all mentors One-on-one interviews with project leaders from AMNH, One-on-one interviews with a sample of residents, Focus group interviews with a sample of mentor teachers	1-4
5. To what extent do clinical experiences focus on specific project objectives, including CRT and implementing CT activities?	Observations of a sample of clinical experiences, One-on-one interviews with a sample of residents and mentors Survey of all residents	3-5
6. To what extent do enacted course experiences align with project objectives and support residents' clinical experiences?	Observations of a sample of course meetings Course evaluations One-on-one interviews with a sample of residents Survey of all residents	3-5

7. To what extent does the induction program, including professional development opportunities, meet newly inducted teachers' needs?	One-on-one interviews with a sample of new teachers Survey of all new teachers	2, 4-5
8. In what ways and to what extent do residents and new teachers benefit from working with school-based and faculty mentors and coaching activities?	One-on-one interviews with a sample of residents and new teachers Survey of all residents and new teachers	3-5
9. In what ways and to what extent do residents and new teachers benefit from being part of a cohort?	One-on-one interviews with a sample of residents and new teachers Survey of all residents and new teachers	3-5
Summative Evaluation Question	**Data Sources**	**Years**
1. Did the project achieve its recruitment target of 72 residents, 24 of whom identify as Hispanic and/or non-white for the MAT-R program?	Demographic data for residents who enroll in the program	3–5
2. Did the project achieve its preparation, certification, and high-needs school hiring target rate of >90% and its 3-year retention rate of >80%?	Certification/licensure outcomes (Performance Measure 1) Program graduation results (Performance Measure 2) One-year persistence rate among any residents that do not graduate in 14 months (Performance Measure 3) Hiring rate (high-needs LEA and overall) One-year employment retention (Performance Measure 4) 3-year employment retention (Performance Measure 5)	3–5
3. What is the impact of the MAT-R program on residents' preparedness to (a) teach science effectively to high-needs underserved students, including ELL students and special education students; (b) use CRT practices; and (c) implement CT activities?	One-on-one interviews with a sample of residents and new teachers Survey of all residents AMNH faculty observation scores Mentor teacher observation scores	3-5
4. What is the impact of the MAT-R program on graduates' preparedness to use CRT practices and implement CT activities, and to teach underserved students, including ELL students and special education students?	One-on-one interviews with a sample of new teachers Survey of all new teachers Hiring principal surveys	4–5
5. What is the impact of MAT-R program graduates on high-needs schools' performance in Earth science?	Results of quantitative comparisons of Earth Science Regents performance in schools with and without MAT-R program graduates, conducted by project partners at NYU (Performance Measure 6)	4–5

Program Impact Evaluation and Research Efforts: AMNH recognizes that engaging in rigorous research within the program enables MAT-R leadership to build upon work by scholarly colleagues in teacher education and science education, to learn from the program's

existing efforts, to share learning with others in the field, and to model the practice of engaging in inquiry into teaching and learning for residents and partners.

Impact Evaluation: Dr. Meryle Weinstein will lead the continued impact evaluation efforts to attain test score data from students of MAT-R graduates and compare them to data of students of non-MAT-R graduates. This work will inform the program about its effectiveness in preparing new Earth science teachers to positively impact student learning outcomes.

Research Plan: The program's focus on CRT allows for inquiry on the intersection of CRT with science teaching practices. Many teacher educators have been studying and redesigning their courses to help pre-service teachers learn ambitious science teaching practices. Yet some teacher educators have raised concerns about how to ensure such practices attend to the contexts of teaching and that student-teachers develop a holistic vision of good teaching (Zeichner, 2015). Others have pointed out the need to ensure that these practices focus on equity and fully reflect students' funds of knowledge and cultural capacity (Phillips, 2019). AMNH MAT-R is well suited to explore this particular challenge; MAT-R graduates teach in some of the most diverse classrooms in the country: 16 percent of NYC public school students are Asian, 26 percent are Black, 40 percent are Latinx, and 15 percent are White. 74 percent are economically disadvantaged or qualify for free or reduced-price lunch. 19 percent are students with special needs and 13 percent are ELL (NYCDOE, 2019). Estimates suggest over 800 languages are spoken across NYC boroughs, with almost 40 percent of the city population born abroad (NYCDOE, 2019). Early evidence from program research suggests that there may be practices to build upon that are already at work in graduates' classrooms and in the residency schools. This provides an important foundation to examine the teaching practices that may be successful in the classrooms where residents and graduates are teaching diverse learners, and to

test and document practices that may expand the program's understanding of CRT for science classrooms. While more states are adopting and adapting NGSS, the field lacks guidance on the kinds of instruction and assessments that are culturally responsive and applicable in multiple environments, especially in the multicultural, multilingual settings of NYC schools.

The goals of the research project are to plan and collect baseline data across the program, field test methods, and implement a multi-year research study. Year 1 will be dedicated to reviewing current research on culturally responsive science teaching practices (e.g. Bell, 2019; Kang, 2019; Thompson et al., in press). Year 2 will be dedicated to documenting the learning opportunities provided by the program, focusing on practices that are especially effective in helping teachers be successful in diverse settings. In Year 3, the research team will focus on a study of MAT-R partner schools, conducting interviews and observations with mentors, administrators, and residents to learn about science teaching practices that they find especially powerful and culturally responsive. Year 4 will involve a study of graduates in hiring schools to gather insights from alumni on their experiences as teachers and in the MAT-R program, data from their students, and perspectives on practices and resources they consider effective for CRT in science classrooms. Potential instruments for the research include the Tripod Diversity, Equity, and Inclusion (DEI) survey (Tripod Education Partners, 2019) designed to document pupils' perceptions and experiences around DEI in their schools, and a survey for student-teachers (Matsko, Hammerness, & Lee, under review) designed to capture residents' perceptions and characterizations of their preparation. Finally, Year 5 will be dedicated to data analysis, writing, and dissemination.